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Contents

SHRIMP SESSION

The Role of International Commissions in World Fisheries, Donald L. McKernan 1

Synoptic Rationale of Existing Florida Shrimp Regulations, Robert M. Ingle 22

Promote Your Product or Lose Your Market, J. Roy Duggan 27

A Report on Federal Programs of Financial Aid to Commercial Fisheries, C. E. Peterson and Luther L. Long 30

INDUSTRIAL FISHERIES SESSION

Potential for Fish Solubles — Liquid Fish in the Fertilizer Industry, Roy C. Stevens 36

Effect of the 1960 Law of the Sea Conference on the High Seas Fisheries, Wilbert M. Chapman..... 38

Fractionation and Purification of Triglycerides, Fatty Acids and Methyl Esters from Fish Oils, Edward H. Gruger, Jr. 53

The Multiple-Use of Shrimp Trawlers, John S. Robas 59

A Challenge to the Fish Meal and Oil Industry in the Gulf of Mexico, John W. Reintjes and Fred C. June 62

TECHNOLOGY AND EXPLORATORY FISHING SESSION

New Methods of Purse Seining for Tuna in the Eastern Pacific Ocean, Gordon C. Broadhead and Arthur R. Marshall 67

Air-Bubble and Electrical-Field Barriers as Aids to Fishing, Keith A. Smith 73

Fishery Products and Food Additives, L. M. Beacham..... 86

The Economic Potential of the Calico Scallop Fishery of the Gulf and South Atlantic with Special Reference to the East Coast of Florida, Jack T. Brawner 90

A Progress Report on Experimental Fishing for Sardine-Like Fishes in the Gulf of Mexico, Harvey R. Bullis, Jr. 94

SHELLFISH SESSION

Status of Researches on Oyster Diseases in North America, J. G. Mackin 98

Delaware Bay Oyster Mortalities, Harold H. Haskin (Abstract) 109

Rehabilitation of Disease—Depleted Oyster Populations in Eastern Canada, R. R. Logie, R. E. Drinnan and E. B. Henderson 109

Recent Advances in the Control of Shellfish Predators and Competitors, Victor L. Loosanoff 113

Economic Aspects of Markets for Middle Atlantic Oysters, John D. Abrahamson 128

The Future of the United States Oyster Industry from a Biologist's Viewpoint, John B. Glude 131

Industry's Appraisal of the Future of the Oyster Industry, David H. Wallace 135

CARIBBEAN AND GENERAL SESSION

How Can Research Production Be Measured?, George A. Rounsefell 139

Tagging of Anchovetas, *Cetengraulis mysticetus*, in the Gulf of Panama, Edward F. Klima and William H. Bayliff 151

Movements of Seatrout on the West Coast of Florida, Alan Moffett and Albert C. Jones (Abstract) 156

A World-Wide Approach to Fish Culture Improvement, Cecil Miles 156

The Contribution by the Outboard Motor to the Mechanization and Development of the Fishing Industry, Ernst Ott 163

Effects of Pesticides on Commercial Fisheries, Philip A. Butler 168

Registrants 173

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MONDAY—NOVEMBER 14

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The Role Of International Commissions In World Fisheries

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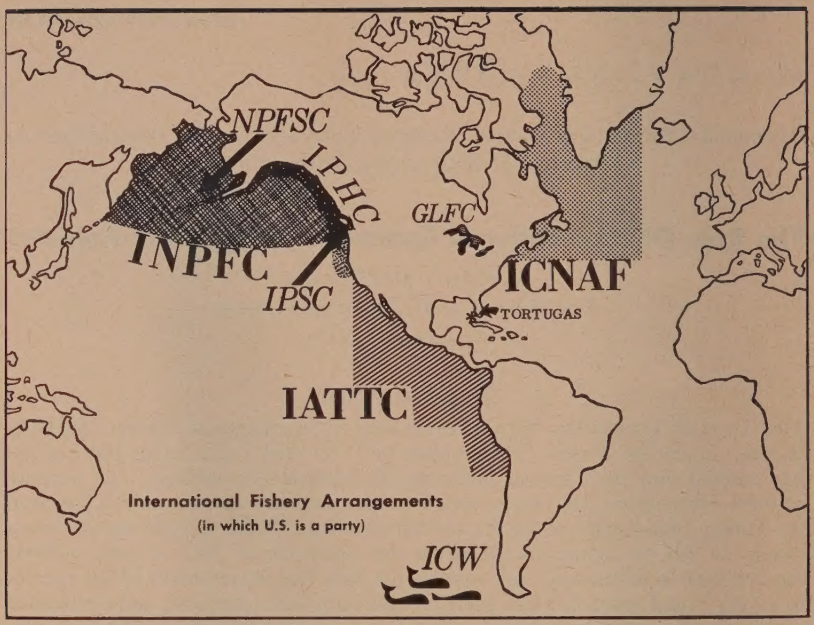
Washington, D.C.

INTRODUCTION

THE UNITED STATES has been participating in international treaties involving fisheries since the Treaty of Versailles in 1783. Since that time, this Nation has entered into nine special international fisheries conventions. The purpose of these conventions has been to resolve fishery conservation problems between the United States and one or more other countries. Fishery problems involving stocks of fish of common concern to the fishermen of two or more nations are complex in nature and they involve not only the conservation of the species in a very broad sense but also political and economic problems, and sometimes problems of special jurisdiction beyond the territorial limits of the countries involved. Nevertheless, the international fishery convention is a common means of approaching these problems, and in the future, as the nations of the world develop a need for protein, the living resources of the sea will be harvested by a greater number of nations and to a greater extent. Thus, problems between coastal and fishing nations of the world can be expected to increase, and it must be anticipated that additional special fisheries conventions will be formed to resolve these problems. For this reason, it is appropriate to examine the international fisheries convention as a means of dealing with these international problems and to examine to what extent they have brought about lasting solutions to some of these problems in the past.

International fishery problems arise from several sources. Essentially, however, these problems are brought about because of the competition on the fishing grounds for the harvest of the limited resourses from a common stock, or common stocks, of fish. For example, the fishing countries of Northern Europe have competed with one another on common fishing grounds for centuries. Several kinds of international commissions have arisen in the Northern Hemisphere to overcome this problem.

In the Northwest Atlantic, where fishermen from over 12 nations fish the Grand Banks and great Continental Shelf of the Northwest Atlantic adjacent to Canada and the United States, the Northwest Atlantic Fisheries Commission is an example of an attempt to resolve fishing problems brought about by the fishermen of many nations fishing common grounds. Probably, however, the greatest success seen from the use of an international fisheries commission as a means of resolving fishing problems between countries are the examples of commissions established to resolve special fishery problems in the Eastern



Pacific Ocean where several countries fishing common fishing grounds in tropical and temperate Pacific waters have developed bilateral and multilateral fishery conventions. Several of these have been unusually successful in providing higher sustainable yields from the fisheries and greater stability in the fishing industries dependent upon these resources. The International Whaling Commission, formed in 1930, in which there has been participation by about 17 nations, is another example of nations of the world attempting to resolve conservation and economic problems through a multilateral form of international fishery convention.

Objectives and responsibilities vary among these various conventions, and some have been very successful while others have not achieved notable success in fully meeting the complex problems for which they were formed.

If one is to understand the background leading to international fishery problems, one must recognize the increasing competition between countries for the fishery resources of the ocean. The present world catch of fish is in the neighborhood of 40 millions of tons of raw fisheries products, the bulk of which is taken in the Northern Hemisphere.

The fishing nations of the world in recent years have expanded their high-seas fishing fleets manyfold, and distant-water fishing fleets of several of the major fishing countries fish all major oceans of the world. The increase in high-seas fishing with technological advances in navigational and fishing techniques has drawn these fleets into competition with one another to an increasing extent at places on the high seas where the productivity is especially great.

For example for centuries the Northern European countries have been fishing the Grand Banks of the Northwest Atlantic. Our country, of course, was also an early participant in the harvest of these fisheries, and historians have recognized that one of the major reasons for settling the New World was the unusual occurrence of fish off the coast of Northeastern United States. Since that time, great developments have taken place in the fishery harvest in this area, and within the past few years several countries, such as the U.S.S.R., Japan, and Poland, have either started fishing in the Northwest Atlantic or have indicated a great interest in these fishing areas. Recent problems arising from the fishing activities of various countries around the shores of Iceland (i.e., the "Codfish War") have pointed up the importance of resolving international problems involving the conservation of the resources of the sea. Iceland, solely dependent upon fishing for her national economy, has become greatly concerned about the reduction of fishing for the groundfish resources adjacent to her shores. Her unilateral steps in expanding the jurisdiction over the waters adjacent to her coast has brought into sharp focus the kind of conflict arising between coastal and fishing nations of the world not only in the North Atlantic but elsewhere on most of the world's major fishing grounds.

Table I. World catch and principal countries, 1957, 1958, and 1959

	1957	1958	1959
		(In metric tons)	
World catch	30,830,000	32,100,000	35,330,000
Principal countries:			
Japan	5,399,000	5,505,000	5,875,000
China (mainland)	3,120,000	4,060,000	5,020,000
United States	2,754,900	2,703,600	2,889,700
U.S.S.R.	2,531,000	2,621,000	2,756,000

Source: FAO 1959 Yearbook of Fishery Statistics.

Japan, who before the war fished mainly in the Western Pacific Ocean adjacent to the shores of Asia and around the tropical islands north of Australia, has now expanded her high-seas fishing fleets and is fishing great distances from her home shores. Her fleets of distant-water fishing vessels have expanded manyfold during the post-war years to the point where her fleets are fishing all parts of the Pacific Ocean — from the Bering Sea to the Antarctic. Recently, Japan's fishing fleets have entered the Atlantic and are intensively fishing off the east coast of South America and the west coast of Africa. Within the past few months Japan has indicated a great interest in the bottomfish resources of the Northwest Atlantic. We can expect that within a very short time she will join other fishing nations of the world fishing the Grand Banks of the Atlantic off the shores of North America.

The Soviet Union is becoming a major fishing nation of the world, and has nearly equaled the United States in total catch. The U.S.S.R. is determined to become the major world fishing power and, indeed, she is well along the way to accomplishing this objective. Her fleets have expanded enormously within the last 5 years, and at the present time the Soviet fishing fleet is, on the whole, the most modern fleet in the world. In the years between 1948 and

1956 the Soviet fishing fleet increased nearly fourfold. She has expanded her high-seas fishing through the use of large factory ships, modern trawlers, and seiners of large tonnage into the Eastern Bering Sea and in the Pacific, and recently has been exploring the broad expanses of the tropical Atlantic — interested not only in the tuna fisheries but also the sardine and bottom fisheries of the tropics. Her fleets entered the Northwest Atlantic groundfish fisheries in 1956 and she is now a major fish producer in this area.

The United States itself has expanded its high-seas fishing fleets since the last war. Whereas the tuna fleet, located in Southern California, formerly fished mainly off the coast of California, and to a lesser extent off Baja California, now the United States fleet has extended its range and large vessels, carrying as much as 600 tons of tuna, are fishing far south on the high seas off the west coast of South America to the northern coast of Chile. In another recent development, American fishing firms have become interested in the potentially productive fisheries of the west coast of Africa, off the so-called "Bulge of Africa." There have been several exploratory cruises by American fishing boats in this area, and we may expect the development of an American fishery here within the next few years.

The United States shrimp fishery is composed of over 4,000 vessels over five net tons and about 3,000 boats of smaller size. In recent years the United States shrimp fleet has developed fully the shrimp resources of the Gulf of Mexico. Our vessels have left our shores and have extended their fishing activities far down the eastern coast of South America in the Atlantic Ocean. At least 80 United States fishing boats are now fishing shrimp in this area. Here, again, we may expect further expansion of these fleets as the market demand for shrimp continues to increase.

These examples of expanding world fisheries on all oceans point up the problem. The fishing nations of the world are expanding their high-seas fishing fleets and are fishing to an increasing extent off the shores of other coastal nations. Not only is there direct competition for the resources of the sea, but there is an increasing need for thorough knowledge of these resources, so that the maximum sustainable yield can be achieved and the maximum sustainable harvest of the resources will not be impaired.

Fisheries Problems of International Nature

International controversy over fisheries of common concern arises from at least three different problems which often are ill-defined and even more often misunderstood. The first and most common problem is that of the conservation of the resource. Here, it is the purpose of the nations fishing on a common fishing ground or on a common resource on different fishing grounds to achieve the maximum sustainable harvest from these resources. The second obvious situation arises where intense competition between fishermen fishing a common resource reduces the profit below an economic level for the fishermen of one or more of the participating countries. And third, there are political problems which affect the relationships between nations fishing common fishing grounds. All of these problems require some mechanism for their resolution, and the various forms of international commissions have become a popular organ for this purpose within the past 50 years.

There are many examples of international fishery conventions which have followed the serious decline and, in some cases, depletion of fishery resources of common concern to several countries. The first and perhaps best known

to us involves the fur-seal resources of the North Pacific Ocean. Intensive sealing by countries bordering the North Pacific Ocean before and immediately after the turn of the last century had reduced the herd from well over one million animals, depending upon whose estimate of the herd size you wish to take, to an estimated 200,000. Obviously some arrangement between the nations killing fur seals was necessary or the resource would be destroyed. Out of this realization arose the first fur-seal convention between Japan, Russia, Great Britain (for Canada), and the United States. The convention was the result of negotiations between these four countries and went into effect in 1911, and except for a short period during the last war, there has been some kind of convention protecting the fur-seal resources of the North Pacific since that time.

The North Sea fisheries of the North Atlantic Ocean provide another example of international action in the face of a declining fish catch. Lucas (1955) states the problem of overfishing was giving concern to North European fishing countries even before 1900. Although there had been extensive research done on the effects of fishing on the stocks of fish of the North Sea, it was not until 1954 that a conservation convention became effective. Even now, it is generally agreed, the current convention falls somewhat short of the conservation measures needed to achieve the highest sustainable yield from the fishery resources of the North Sea.

Political differences arise from two or more countries fishing common stocks of fish. Many coastal nations of the world, in contrast to the old established fishing nations, such as the United States, Great Britain, and Japan, do not have modern fishing fleets and cannot compete efficiently with modern high-seas, distant-water vessels. In many instances, these coastal countries are only recently aware of the potential of the fishery resources lying off their coasts. They often have neither the trained fishermen nor the vessels to harvest these resources efficiently. Only too often many of their people suffer from protein deficiencies. They are beginning to realize the potential wealth of the sea and do not wish to have these resources either dominated nor depleted by aggressive fishermen from established fishing nations. These countries have reacted in a number of ways — the most common of which has been to expand the limit of the territorial sea or claim jurisdiction over fisheries out to varying distances, in some cases to 200 miles beyond their coastline.

Since we know so little of the resources of the sea, it is small wonder that many small nations question the ability of the fisheries resources off their coasts to withstand the intensive fishing by large modern fishing fleets of far-distant countries. The great area of our ignorance of the resources of the ocean makes the problem of resolving all kinds of differences between coastal and fishing nations more difficult. It appears that the only reasonable solution is the joint study on a broad scale of the oceans and their resources.

The economic problems involving fisheries of common concern to two or more countries are often the cause of serious difficulties between countries. For example, in the North Sea the markets of some countries prefer the harvest of groundfish of very specialized sizes, even though the rational harvest for maximum sustainable yield of this resource might suggest that the optimum size was larger and the optimum age older. However, in order to achieve this a country must give up the harvest of the sizes and kinds of fish most desirable for its market.

The problems which will arise from such a consideration can easily be seen. In fact, in the case of the bottom fisheries of the North Sea, the economic problems involved have prevented a complete solution based upon the known biological data.

The post-war history of the Antarctic whaling shows the effect of not only a lack of proper conservation by the whaling countries but also of the sharp effect of economic differences between countries. These conflicts have resulted in great reduction in the numbers of some species of whales, especially blue whales, plus increased numbers of whaling fleets. This intense competition is forcing some of the countries from the Antarctic whaling grounds. Similar economic problems are bound to arise as the resources are jointly harvested by fishermen of various nations fishing with more or less efficient fishing methods. Those fishermen who for one economic reason or another can fish the stocks on a common fishing ground to a lower level of abundance and still compete economically have a definite advantage, and unless some mechanism such as the international fisheries commission is found to overcome these conflicts, intense feeling between the fishing countries can be predicted, resulting in competitive action oftentimes detrimental not only to the fishing industries of those countries concerned but to the resources as well.

Our own early history is closely bound to the international disputes in the fisheries of the Grand Banks and Northwestern Atlantic Ocean. In the early history of the New World the disputes were between the British, including the settlers of New England, and the French. In recent times the disputes have been mostly between our country and Great Britain, including Canada. The political questions at issue have related not only to the right to take fish in waters adjacent to the land, but also the right to certain other privileges in the waters and on land. They are not all resolved yet, although the International Commission for the Northwest Atlantic Fisheries has provided a welcome forum. With these problems in mind, it seems obvious that there is an increasing need for international cooperation on a very broad scale and for organizations, whatever their form, where some of the most fundamental questions relating to the productivity of the resources of the sea and the jurisdiction and ownership of these resources can be debated.

Means for Solving International Fishery Problems

One of the most common means for a country to attempt to solve problems arising from the encroachment of foreign-flag fishing vessels has been to claim jurisdiction over a broader width of the seas adjacent to its shores. While in the past most coastal countries recognized a 3-mile territorial limit, some did not. Indeed, many coastal states have recently proclaimed jurisdiction upwards to 200 miles at sea. The most common claim beyond 3 miles has been 12 miles, claimed by Russia, many of the nations following her political philosophy, several Arab countries, and advocated by many more countries.

There have been strong political overtones to the claims of the Soviet Union and the Arab bloc, but many countries, such as Mexico, Canada, Iceland, Norway, and others, have used the extension of territorial seas and special jurisdiction over fisheries as a means of solving international fisheries conservation problems. This is not to say that in certain cases there was not a basis for the concern over the resources; quite the contrary, this is to say that unilateral action by the coastal state to either extend her territorial seas or

extend jurisdiction over fisheries has become one of the most common means towards the solution of international fisheries problems.

A great step forward in settling the general problems relating to the activities of nations on the high seas occurred during the 1958 United Nations Conference on the Law of the Sea. This conference adopted five general rules governing the activities of nations on the seas of the world. Its most significant features relate to the freedom of the seas with respect to fishing, navigation, and other matters. It also adopted conventions on fishing and conservation, defining the "Continental Shelf" and the resources of the shelf. Further, this Conference adopted rules for compulsory settlement of disputes between countries party to the conventions and dealing with matters within the scope of the conventions. Obviously this is a big step forward. For the first time the nations of the world laid down principles based upon equity by which countries could conduct themselves in harmony on the high seas.

There were, however, two matters upon which agreement could not be reached during the 1958 conference; the breadth of the territorial sea and the extent of jurisdiction over fisheries. The position of the fishing states, including the United States, was to adopt a narrow territorial sea while the coastal states, including several South American countries, were in favor of expanding the limit of the territorial sea or extending the jurisdiction over the fisheries resources, or both.

Because of a failure of the 1958 Law of the Sea Conference to reach agreement upon two vital issues, a second conference was convened in March 1960 to further consider these matters. Again no agreement was reached on the width of the territorial sea or the extent of the jurisdiction over the fisheries. However, a majority of countries was in favor of a United States-Canadian proposal which in general called for a 6-mile territorial sea and 6 miles additional jurisdiction over fisheries after a 10-year waiting period. (The rules of the Conference called for a two-thirds majority vote for adoption. This proposal finally failed by one vote.) Even though there was no final agreement concerning the width of the territorial sea nor the breadth of jurisdiction over the fisheries, the five conventions adopted at the 1958 Conference form a framework from which general agreement between countries fishing common resources can be achieved.

Another approach has achieved modest success in dealing with international fishery problems. Herrington and Kask (1956) discuss the formation and function of the Research Council and Regional Fisheries Council as a method of dealing with regional fisheries problems. These Councils were formed in the first place to exchange biological and other scientific information and to aid in the coordination of research efforts between countries fishing common stocks of fish on common fishing grounds. The best known of these early Councils was the International Council for the Exploration of the Sea, formed in 1902.

More recently, with the formation of the Indo-Pacific Fisheries Council in the Western Pacific in 1948, and another new Council, the General Council for the Mediterranean, both of which are sponsored by the Food and Agriculture Organization of the United Nations (FAO), the objectives and scope of these Councils have gradually broadened. Their purpose is not only to exchange scientific information about resources of common concern, but they stimulate joint research projects and are becoming a major force in the development of

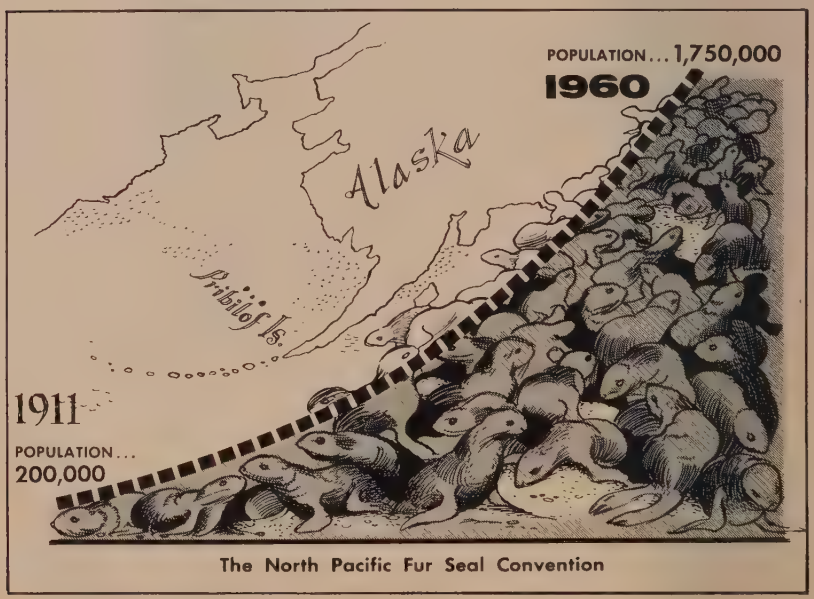
programs for expanded use of the living resources of the seas and for their proper utilization.

Of more immediate concern to the fisheries of the United States, however, has been the development of the bilateral and multilateral fishery convention wherein the objective of the convention is the conservation of certain stocks of fish of common concern to two or more countries. These conventions, unlike the Fishery Research Councils mentioned above, have specific conservation objectives and management responsibilities so that recommendations of the commissions can be readily implemented. All of the nine fisheries conventions directly involving the United States provide in one way or another for the enforcement of regulations pertinent to the fisheries with which they are concerned. Several of the recent conventions, the North Pacific Fisheries Convention (1952), North Pacific Fur Seal Convention (1957), and the Great Lakes Fisheries Convention (1955), provide for a periodic review of the Commission's progress in achieving its objectives, whether it has accomplished its goal, or whether it should be continued as is or with modifications.

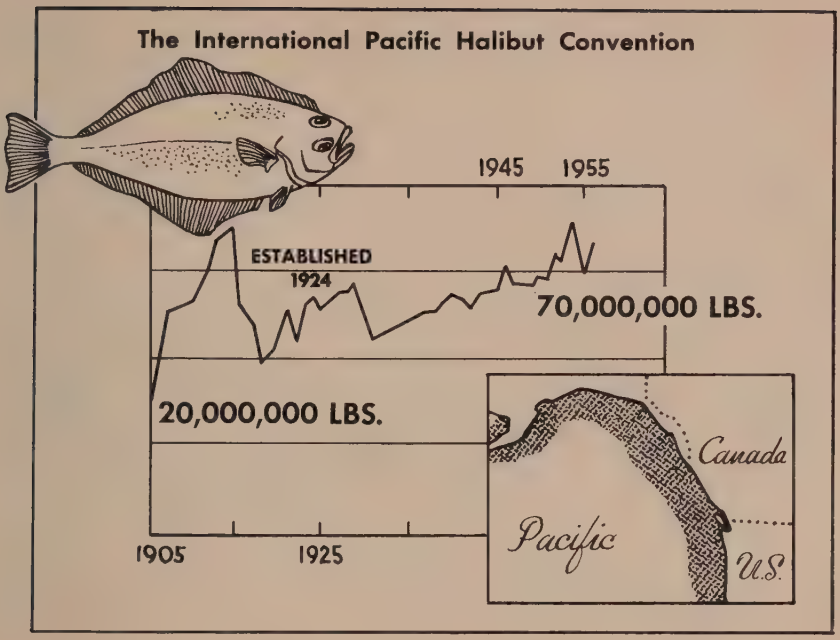
Although it is not the purpose of this discussion to detail the fisheries commissions in which the United States participates (this has been done by Terry (1953), Herrington (1955), and Herrington and Kask (1956)), it is pertinent to the discussion to briefly review their current status.

The North Pacific Fur Seal Convention

The original convention between Great Britain (for Canada), Japan, U.S.S.R., and the United States was signed in 1911 after serious depletion of the herd of fur seals of the North Pacific Ocean had occurred during the latter



The North Pacific Fur Seal Convention



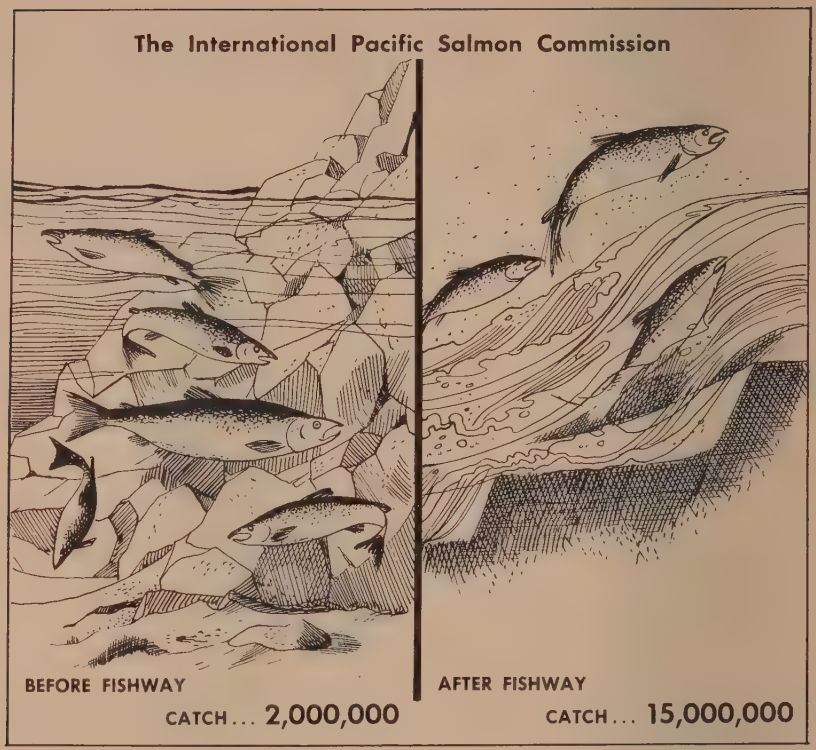
half of the 19th century. In 1941 the Convention of 1911 was terminated and it was not until February 1957 that an Interim Convention was signed. The present Convention is subject to renegotiation in 1963.

The main fur seal herd breeds in the summer on the Pribilof Islands, migrating south along the Pacific coast of North America with a portion of the herd moving south in the Western Pacific off Japan. The intensive harvesting of the seals both on the breeding islands as well as pelagically brought about the decimation of the herds near the end of the 19th century.

Since the inception of the original Convention, the Pribilof herds of fur seals have increased from an estimated 200,000 animals to about 1,750,000 animals in recent years. The harvest of fur seals was eliminated immediately after the first Convention went into effect. Recently, however, as a result of the increase in the herd, the harvest has been in the neighborhood of 60,000 animals. Biologists have estimated that the herd has grown too large and with the advice of the Commission the United States Government is seeking to reduce the total from about 1,750,000 to about 1,500,000 animals.

The International Pacific Halibut Convention

The Pacific halibut fishery became important to the United States and Canada soon after 1888 when a commercial fishery began off the northwest coast of the State of Washington. After a record catch of 69 millions of pounds in 1915, the catch dropped precipitously and remained at a low level until



well into the 1930s. Since then the catch has risen and the present catch is again in the neighborhood of 70 million pounds.

The original halibut convention entered into force in 1924 and subsequent conventions have been ratified in 1931, 1937 and 1953. The primary objective of the original convention was "to preserve and restore the Pacific halibut fishery to the peak level of production prior to the convention." At the present time the concern of the Commission is to maintain the maximum sustained yield of Pacific halibut and provide proper management to the resource.

International Pacific Salmon Commission

The Convention between the United States and Canada was signed in 1930. Its objective was to determine the cause for the decline of the Fraser River sockeye salmon runs and to find ways of restoring these runs. An intensive research program was begun in 1938, and by 1945 the construction of the Hell's Gate fishway had eliminated the barrier to the upstream migration of sockeye salmon. In recent years, after the correction of the Hell's Gate block, the objectives of the Commission have turned more to regulation and management in order to rebuild the separate races of sockeye in the Fraser River

system. Prior to the occurrence of the slide at Hell's Canyon on the Fraser River, the peak annual production of salmon reached 20 million fish. After the full effects of the block were felt, the catch declined to less than 2 million fish. Current production has reached 15 million fish, almost to the high level of production of earlier years.

In 1957 the original Convention was amended to include pink salmon in the Convention area. At the present time studies are underway to determine the proper conservation measures necessary for the maximum sustainable yield of this species.

International Commission on Whaling

Whaling was carried out by New England vessels early in the history of our country. The great sperm whaling grounds along the equator in the Pacific Ocean provided large catches of whales until the late 19th century. However, the modern period of whaling began with the development of the harpoon gun and the large mechanized factoryship. The excessive and unrestricted catch of whales had so reduced the number of whales that by 1930 it was obvious to all whaling countries that some limits were needed to protect the remaining animals. A conference was held on this subject in 1930, and finally in 1937 a Convention was adopted and signed by nine of the signatory nations to the 1931 agreement. Subsequent revisions have resulted in the 1946 International Convention for the Regulation of Whaling. The first meeting of the International Whaling Commission, which arose from this Convention was held in Washington in 1949. Seventeen countries have adhered to the Convention, although at the present time several countries have withdrawn or are threatening to withdraw.

The Convention provides for recommending research programs, reviewing scientific findings, setting whaling seasons, fixing areas, limiting numbers of

whales which can be killed, and in general has broad powers of regulation and enforcement over the whaling operations of all signatory countries.

It has been a very powerful deterrent to the unrestricted harvest of whales, but because of the wide diversity of economic interests among the 17 nations involved, the Commission has not been successful in arresting the decline of some of the major whale herds, especially the blue whales of the Antarctic Ocean.

The Inter-American Tropical Tuna Commission

The tuna fishery of the west coast of the United States began at about the turn of the century and since has become one of our largest and most important fisheries. The fishery which began fishing albacore off California now ranges both north and south, catching albacore as far north as Vancouver Island in Canada and yellowfin and skipjack tuna south along the Central and South American coasts as far as Northern Chile. The growth of the fishery has been rapid and a peak catch of 390 million pounds was reached in 1950. Since then the catch has fluctuated between 250 and 300 million pounds. Apparently the catch dropped not because of a shortage of tuna, but because of an influx into the United States of large amounts of foreign-produced tuna at prices below the cost of production of the American fleet.

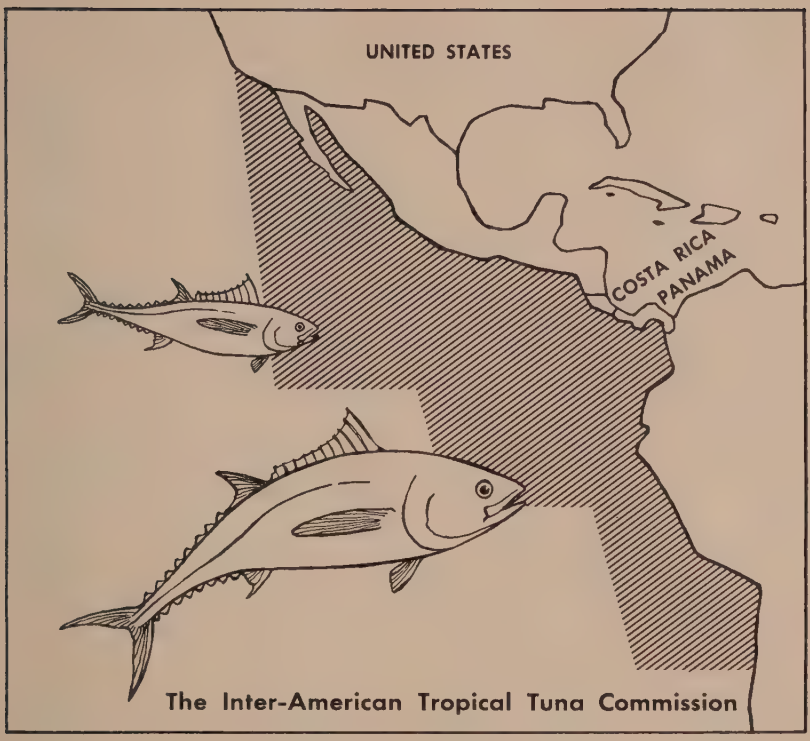
The very rapid rise in fishing for yellowfin and skipjack in the eastern tropical Pacific caused the United States and several of our neighboring countries to the south to voice concern about the conservation of these stocks of tuna. As a result of this concern, there was negotiated in 1949, and ratified in 1950, a Convention between Costa Rica and the United States which established the Inter-American Tropical Tuna Commission. The objective of this Commission is to "gather and interpret factual information in order to facilitate the maintenance of populations of yellowfin and skipjack tunas, and other kinds of fishes taken by tuna fishing vessels in the Eastern Pacific Ocean, at a level which will permit maximum sustained catches year after year." (Shaefer, 1955). The Commission is directed to undertake necessary scientific investigations for this purpose and, on the basis of these investigations, to recommend proposals for joint action.

The Commission began its investigations in 1951 and has made great advances in the knowledge of the tunas of the tropical Eastern Pacific. There can be little question but that it has been successful in ascertaining the level of abundance of yellowfin tuna and estimating its optimum yield. The Commission also has successfully predicted that the fishing effort on skipjack tuna is well below the level which will produce the maximum sustainable catch of that species.

International Commission for the Northwest Atlantic Fisheries

The fishing banks given consideration under this Commission have been harvested for over 400 years. There has been some speculation that European fishermen visited and fished the Grand Banks area prior to the voyages of Columbus. It has often been stated that the Pilgrims who settled New England came to the New World to worship God and to fish.

The species which have been most actively sought from these grounds since earliest times are the codfish, haddock, halibut, and, more recently, the redfish. Other fishery products of notable importance include the pollock, whiting, hake, and scallop. Traditionally, these fishing grounds on a broad, wide



continental shelf have been considered among the most productive in the world.

Early fishery activities by several European countries, notably Portugal, France, and England, brought to focus the competitive aspect for the fishery resources of the "New World." Throughout the early history and development of North America certain concessions and agreements were established between nations desirous of utilizing the abundant marine resources available in the Northwest Atlantic Ocean. However, it was not until 1920 that representatives of Canada, Newfoundland, and the United States met in Ottawa to consider cooperative investigations of the Northwest Atlantic fishery resources. A series of informal meetings was held culminating in the formation of the "North American Council on Fishery Investigations" at Washington in 1930. This organization disbanded just prior to World War II. Through it, however, the foundations of the International Commission for the Northwest Atlantic Fisheries were established.

Recognition of the problem of reduced abundance and potential depletion of the fisheries of the North Atlantic prompted the convening of three international conferences in 1937, 1943, and 1946. These conferences considered problems related to the entire North Atlantic. In 1946, in line with a suggestion offered by the United States of America, the Conference decided to restrict its

consideration to the area east of 42 degrees west longitude. This decision was taken in recognition of the benefit of separating the North Atlantic into eastern and western sections for conservation purposes.

In order to consider problems affecting the fisheries of the Northwest Atlantic, a conference of 11 countries was convened at Washington in January 1949. The work of this conference resulted in the opening for signature on February 8, 1949, of the International Convention for the Northwest Atlantic Fisheries, and the Convention entered into force on July 3, 1950, after the deposit of instruments of ratification by four signatory governments, namely, Canada (including Newfoundland), Iceland, the United Kingdom, and the United States of America.

The objective of the Northwest Atlantic Fisheries Commission is to work with member governments towards achieving maximum productivity of the fisheries of the Northwest Atlantic. It does this by programming research, and collecting and arranging for the rapid exchange of scientific information between scientists of the various member governments.

The Northwest Atlantic Commission has 12 member nations, with several more nations, including Poland and Japan, either now fishing the Northwest Atlantic or seriously considering doing so. In addition to the complexity of the problems occasioned by the large number of nations engaged in the fishery, there is the additional problem of attempting to achieve the maximum yield from the fishing grounds when at least 7 major species of fish are taken in various parts of the fishery by the same kind of fishing gear. A case in point is the Atlantic halibut. Obviously, if the maximum sustainable yield of halibut

is to be achieved, then haddock will be underfished. As a result, it is likely that at the present time halibut is being overfished on Georges Bank, but a greater catch of haddock is being taken.

Even with the many complexities involved and the short time it has been in effect — 9 years — the accomplishments of this Convention are significant. Large research programs by most of the member nations are well coordinated through various panels of the Commission. In addition, mesh regulations have been adopted for two of the areas of the Northwest Atlantic and there is evidence that these conservation measures have led to increased yields of haddock.

International North Pacific Fisheries Commission

The North Pacific Commission has as its objective the conservation of the stocks of fish of the North Pacific Ocean. The Convention, between Japan, Canada, and the United States, introduced a new concept, "Abstention." This concept recognizes that the high levels of productivity maintained in some fisheries of the North Pacific are the result of long and continuous, if not perfect, conservation efforts. In view of the time, effort, and expense involved in these efforts, and recognizing that without them the stocks under consideration would not continue to produce at high levels, the Convention provides for the abstention from fishing these stocks by other member nations where it can be shown that one or more countries are fully utilizing the resource, have it under study, and under scientific management.

Under this Convention, the Japanese agreed to abstain from fishing North American halibut, salmon, and herring stocks. A provisional line was set at 175 degrees west longitude on the high seas, east of which the Japanese agreed not to fish. On the other hand, both Canada and the United States agreed to develop more thoroughly scientific proof that these stocks of fish qualified for abstention. They, with Japan, agreed to study the high-seas distribution of salmon to define areas of intermingling between salmon of Asian and North American origin, and to find a line or lines which would better divide the North American stocks of salmon from those of Asia.

The scientific accomplishments from this Convention have been substantial. The high-seas distribution of Pacific salmon is becoming well understood and the environmental factors influencing their distribution on the high seas are being discovered. Nevertheless, broad areas of disagreement remain between Japan on one hand and Canada and the United States on the other. The Japanese do not agree that Canada and the United States have proved that the stocks of fish now under abstention qualify under the terms of the Convention. Furthermore, the United States has claimed that the present temporary abstention line should be moved farther west, giving more protection to major sockeye salmon stocks of the Bering Sea, and thus better and more equitably dividing the salmon of Asian and North American origin. While disagreement remains concerning the two vital issues in Convention, a broad cooperative scientific program continues on the high seas. This program promises to provide much fundamental knowledge about the fishery resources of the North Pacific Ocean.

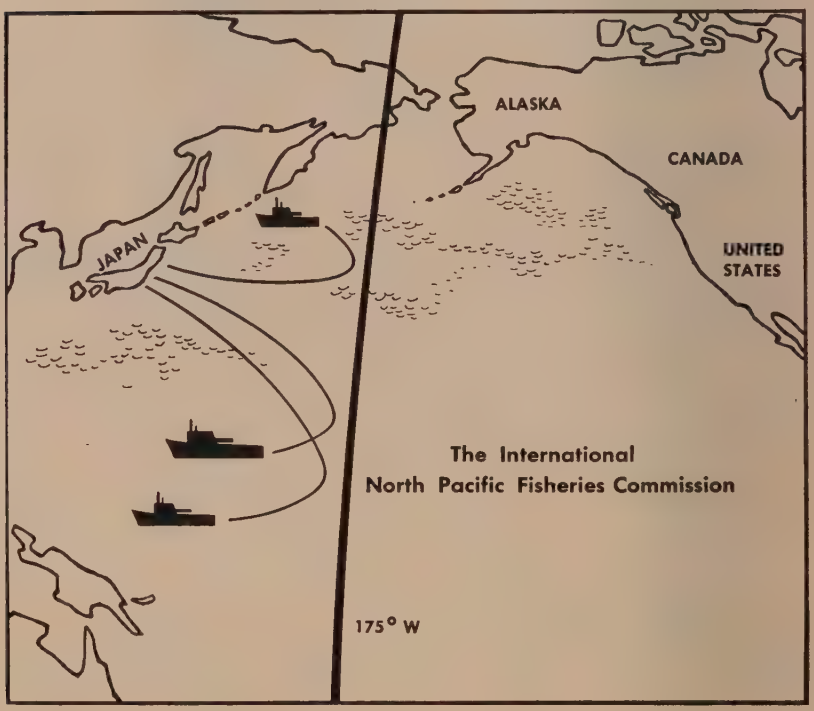
The Great Lakes Fishery Commission

Another recent fishery treaty involves the five Great Lakes bordering Canada and the United States in the midwestern area of our country. All of the Great Lakes, except Lake Michigan, are shared by the United States with Canada.

All of them, except Ontario and Huron, are shared by two or more States. With this in mind, it is apparent that it is unrealistic and indeed impractical for one State, Province, or one of the nations involved to attempt to resolve independently the fishery problems common to the area.

The most practical approach to the situation—cooperative action—was recognized as early as 1875. The first Great Lakes Interstate Conference was called together in 1883 by the Michigan Fish Commission to discuss the need for uniform fishery legislation. A series of meetings was held following the initial meeting. These resulted, in 1940, in the creation of an International Board of Inquiry for the Great Lakes Fisheries. The findings of this Board, submitted in 1942, recommended the establishment of an International Commission for the Great Lakes Fisheries. In 1946 a Convention was signed; it was not ratified by the United States however, due to the opposition of one or two States and certain fishermen groups.

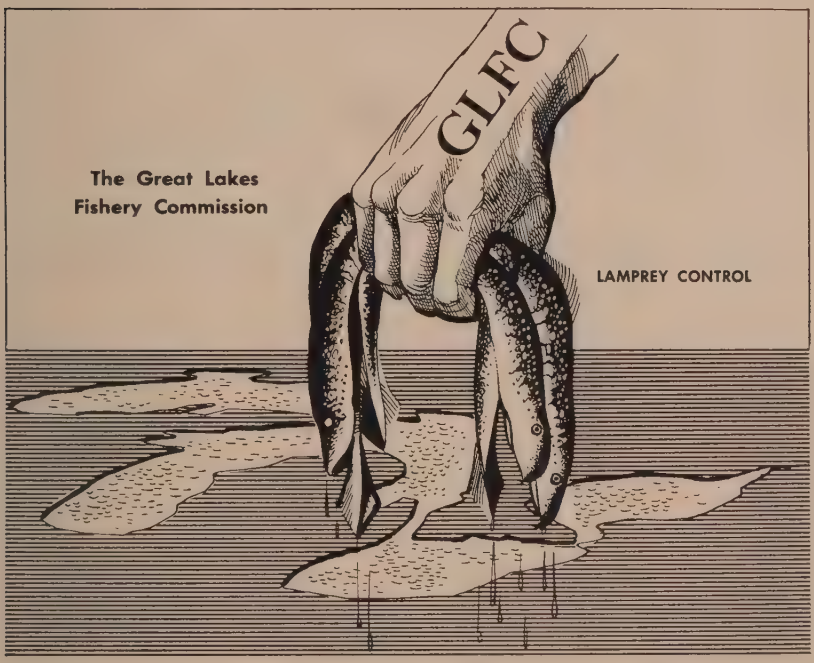
During the years following 1946 the problems of the Great Lakes fisheries became more crucial. The depredations of the sea lamprey, a parasitic predator on the lake trout, had a serious effect on the stocks of trout in some of the Lakes. It was generally recognized that cooperative action was needed. A new Convention was written in 1954, after careful consideration, in an attempt



to make the agreement acceptable to all. The Convention was ratified by both Canada and the United States in 1955.

The Great Lakes Fishery Commission was organized and the first meeting was held in April of 1956.

One of the primary tasks of the Commission is to eradicate the sea lamprey, or at least eliminate its effects upon the Great Lakes trout. Scientists of the two countries, working through the Commission, have developed the electric barrier which prevents the adult lamprey from ascending spawning streams tributary to the Lakes. Another recent and even more successful method has been developed using a larvicide or specific poison which kills the larvae in the mud of the tributary streams.



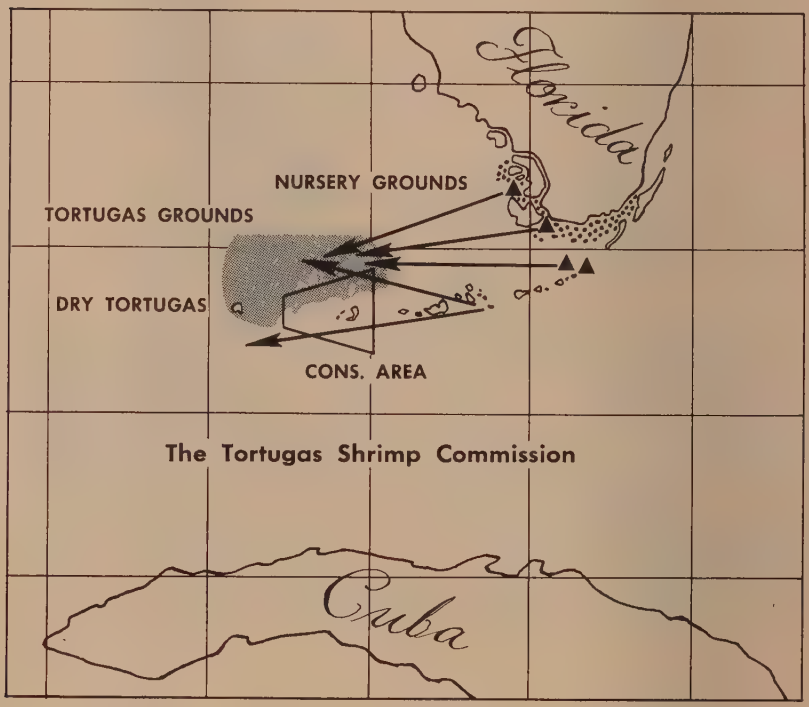
Treatment has been virtually completed in Lake Superior and plans are underway by the Commission to rehabilitate the lake trout fishery of this lake. Chemical treatment is underway in both Lake Huron and Lake Michigan to eliminate the predatory lamprey.

The Commission, as it is presently organized, also has the duties of developing research programs and, when practical, makes recommendations to the participating governments for regulations or other measures to insure sustainable yields from the fisheries of the Great Lakes. Perhaps as the Commission gains stature its functions will be more significant in the management of the

Great Lakes fisheries. Under the present Convention the Commission's authority does not extend to regulatory powers; these at present are retained by the individual States and Provinces affected.

The Tortugas Shrimp Commission

The most recent fishery Convention came into force in September 1959. This Shrimp Convention between the United States and Cuba provides a basis for study and conservation of shrimp stocks of common concern to Cuba and the United States. The implementing legislation for this Commission failed to pass the Congress during the past session. Undoubtedly, the present difficulties between the Government of Cuba and our own Government will handicap the joint efforts toward conservation of the Tortugas shrimp stocks as provided by the Convention.



The shrimp fishery of the United States is our most valuable fishery. It is centered in the Gulf of Mexico, and our boats fish on stocks of common concern to Mexico and other countries bordering on the Gulf. Thus, it is of utmost importance that joint efforts in the conservation of these resources be initiated in order that the productivity of these resources not be reduced.

The present Convention is an outgrowth of fears of State and Federal

Governments, and industry officials that the pink shrimp resource of the Dry Tortugas area off the tip of Florida might be in danger of depletion.

The development of this fishery primarily by the United States shrimp fleet, but also by Cuban vessels, since 1949, has given scientists a rare opportunity to closely observe the development of a marine fishery from its inception. After the discovery of shrimp in the Tortugas area in 1949, the fishery rapidly increased. It is now producing between 15 and 20 million pounds of shrimp each year. State of Florida and industry leaders have been concerned about the conservation of the Tortugas stocks of shrimp and the Tortugas Shrimp Convention has arisen out of this concern.

GENERAL DISCUSSION

It is obvious that with the increase in fishing effort by great fishing nations of the world and the need for an inexpensive source of protein by most peoples of the world, international fisheries problems will increase. It would appear that the oceans are a logical place from which we might easily increase the world supply of protein and this fact is becoming obvious not only to the traditional fishing nations but also to the recently formed independent countries. From these observations we conclude that it is essential that there be international organizations to provide a forum in which these problems can be studied and resolved.

We have examined the various kinds of solutions which have been used by various nations. Some nations have taken unilateral action to drive competitors from fishing grounds on which they believe they had some proprietary right. These actions have taken the form mostly of extended territorial limits of coastal countries or special jurisdiction over certain fishery resources because of special location of the resource or special dependence of the people on the resource. It is concluded that unilateral action by coastal nations or by fishing nations has not been a very permanent nor satisfactory means of solving international fishing disputes.

Another method of resolving fishing disputes between nations has been through the means of the Conferences on the Law of the Sea. The 1958 Law of the Sea Conference adopted a number of Conventions which have contributed to the general problem of the ownership of resources of the high seas and freedom of the seas, but it and the subsequent 1960 Conference failed to resolve the important questions of the width of the territorial sea or the distance to sea of jurisdiction of a coastal state over the fisheries resources adjacent to its coastline. Because of these most important unresolved issues and because few nations have as yet adopted the Conventions accepted at the 1958 Conference, this method of solution to the international fishery problems seems incomplete at best and not too practical.

The regional fishery council has developed as another means of resolving certain differences between fishermen of several nations fishing common stocks of fish. These councils, originating from the Food and Agriculture Organization of the United Nations, may be an important kind of international force in resolving international fishing disputes. It is still too soon to be sure of the future of this kind of organization, but potentially it may well replace the bilateral and multilateral fishery convention as an effective means of resolving regional or world-wide disputes in fisheries.

By far the most effective means of bringing some semblance of order out of

fisheries disputes between nations has been the bilateral or multilateral fishery convention. In all instances examined here, this kind of organization has been helpful in resolving the difficult and complicated problems involved, although complete success has not yet been achieved in several cases. It would appear that for the immediate future, and until the effect of FAO-sponsored kind of regional councils has been thoroughly tested, fishery problems involving fishermen of two or more countries can best be solved by forming international fishery conventions among the countries involved.

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SYNOPTIC RATIONALE OF EXISTING FLORIDA SHRIMP REGULATIONS[1]

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FLORIDA HAS BEEN BLESSED by a legislative branch of government receptive to statutory changes whenever experience indicated that amendments were desirable. The executive branch has, in turn, been willing to undertake and administer new type regulations so long as there seemed reason to believe that the old ones needed improvement.

These two facts, together with the long history we have had in the shrimping enterprise, have resulted in a rather substantial amount of experience in the supervision and regulation of shrimp. Some of the earlier attempts and their deficiencies are summarized in a report given to this meeting in Nassau several years ago (Ingle, 1956).

The summary I will give today is in the nature of a progress report. We do not claim that the regulations as described are infallible or that new knowledge will not be available tomorrow that will require new adaptations. However, when our shrimp rules were put into effect during the past three years they were consonant with existing information and had the benefit of abundant experience.

We do feel that while there will no doubt be changes in some of the details, the basic features of flexibility and sampling are unlikely to be substantially altered.

It should be pointed out that each shrimp habitat is different and regulations must be tailored for local conditions.

Much has been written concerning the justification for fisheries management. It is not the purpose of this report to deal exhaustively with all of the socio-economic factors involved with regulations *per se*, nor do I feel I should enter into the nuances of philosophy involved when the complex biological and fiscal dynamics of *laissez faire* shrimp production are altered by human intervention.

Those persons interested in extremely complicated ramifications of fishery management are referred to the many extant publications on the subject, among which are Herrington (1948), Burkenroad (1951), Smith (1958), and Schaeffer (1959).

Instead, all of our discussion and evidence will be developed with one assumption in mind. This assumption will not be defended, but will be accepted on *a priori* grounds.

A. THE ASSUMPTION: It is desirable to catch the greatest possible number of pounds of shrimp, this desirability being enhanced as the sizes of the shrimp caught are increased.

Let us examine several hypotheses which might be explored in an effort to determine the best means by which to apply Assumption A.

[1]Based in part on an address presented at the Ninth Annual Meeting of the Shrimp Association of the Americas, Mexico City, June, 1960.
[2]Contribution No. 48.

1. Hypothesis:

The stocks of shrimp which form the foundation of the fishery can be increased or decreased by regulation of fishing.

Evidence:

Present information negates this hypothesis. Abundance of individual shrimp created by the fishery appears to be regulated by natural factors. See: Hildebrand and Gunter (1953); Gunter and Hildebrand (1954); Viosca (1945); Lunz (1957), (1959), (1960); Burkenroad (1951); Collier and Ingle, *et al.* (1959) and Lindner and Anderson (1956).

Remarks:

Note the expression "regulation of fishing" in Hypothesis (above). It is felt that man's improvident use and management of shallow protected nursery grounds can affect stocks by reducing potential sanctuaries for immature stages. However, this matter lies outside the province of fisheries regulations which are the subject of consideration here.

Conclusion:

Restriction of fishing by any means is not justified if the purpose be to enhance numbers of spawners or to affect the abundance of the year class. The number of spawners needed to replenish stocks is extremely small, almost total elimination of adults being unable to suppress the following generation. The benefits implicit in Assumption A (above) cannot be derived by regulations aimed at increasing stocks.

2. Hypothesis:

Pounds of shrimp landed can be increased when unrestricted fishing is replaced by managed fishing.

Evidence:

Shrimp growth has received attention from many workers. In weight, the monthly increment varies with size and season. Roughly, from the egg to a size of 50 tails to make a pound requires about six months in warm weather. This may be slowed somewhat during winter. During the early stages of development, shrimp grow at a rate which, in the aggregate, offsets the weight lost by natural mortality. See Gunter (1956). Studies on white shrimp indicate that the mortality rate lies close to 25 per cent per month. See Lindner (1959). At this rate, the size at which harvest should take place is at 50 tails to the pound. When shrimp become larger than this, mortality exceeds weight increment. Although the case is not proven, the weight of evidence lies with protection of the young.[1]

Protection of larger individuals, indigenous to the offshore waters, is thought to be not only of no value in augmenting landings but may actually diminish landings. See Gunter (1956), Burkenroad, *et al.* (1955) and Schaeffer (1959).

Remarks:

Statisticans and biometricians have, in the past few years, developed

[1]Lindner, 1960, reported that his calculations were being revised and that the mortality rate appeared to be higher than he reported in 1959 and the best size to harvest would be lower.

new and improved techniques for the evaluation of fishery dynamics. No attempt will be made here to enumerate these works, but mention can be made of a few. See Schaeffer (1951) and (1954), DeLury (1947) and (1951) and Ketchen (1953).

Similar methods developed in other fields may also be of interest. See, for instance, Eyles and Cox (1943). In the light of the evidence, it seems prudent for us to accept the idea of protection for young, at the same time that we attempt to improve our understanding of shrimp productivity. See Collier and Ingle, *et al.* (1959).

Conclusion:

The protection of shrimp of a count greater than 50 tails to the pound would be effective in attaining benefits implicit in Assumption A (above); that is, a regulation prohibiting fishing of young shrimp would result in more pounds landed and greater financial return.

3. Hypothesis:

In order to achieve the benefits described under Hypothesis 2 (above), which are deemed desirable for Assumption A, a closed area should be established in each shrimp fishery in which no harvest should be permitted.

Evidence:

Several methods have been tried in the long history of small shrimp protection. These have largely been discussed by Ingle (1956). Since that summary, net mesh size minima were also attempted. The results of the latter were indifferent and the methods had several difficult aspects. See Iversen and Idyll, 1959.

From a practical standpoint, the method discussed generally by Burkenroad (1951) and Collier and Ingle, *et al.* (1959), and which was put into operation in Apalachicola, Florida, in 1953 and reported upon later by Ingle (1956), has proven to be the most satisfactory.

It has been in operation since 1957 in the shallow, coastal sectors of the Tortugas fishery and has served well. See Ingle, *et al.* (1959).

Remarks:

The principal feature of the present Florida regulation is flexibility. Since shrimp biology is so closely related to natural fluctuations of currents, nutrients, temperature, dissolved gasses, light and many other factors, a rigid prohibition will, at times, be inapplicable or, worse, of detriment to the industry.

Management, based upon changing conditions on the grounds, can be dependably effective.

The regulation as applied to Florida inshore waters has one other highly desirable feature. Because regular and frequent sampling is carried out as part of the regulation, to keep accurate account of the growth of developing broods, there is available revealing data which can, when properly treated, allow an internal audit of the efficiency of the management program and an evaluation of its success.

It also permits the regulation to develop and change as greater understanding directs. See Collier and Ingle, *et al.* (1959) and Burkenroad (1951).

Conclusion:

A flexible closure of shallow nursery grounds will, in the light of present understanding, provide more pounds of shrimp for the fishing fleet. These shrimp will be of larger average size than would be available without the restriction. Both benefits set out in Assumption A (above) will be derived from such a regulation. This type of management also permits a continuous evaluation.

Recommendations:

In spite of the fact that some information exists to support the protection of small shrimp more detailed quantitative evaluations are still needed.

Because of the complexities of the population dynamics involved, it is anticipated that a massive sampling program such as that outlined earlier by Ingle (1959) and involving extensive tagging will be required.

A particularly vexatious factor, and one which partly interferes with the use of landings data in population studies, is the nature of recruitment to the fishing area. As is well known, shrimp enter the Tortugas fishery (and other shrimp fisheries) over relatively long periods each year. Also, the sizes vary widely at which they leave shallow, protected areas and become available to the fleet and to sampling projects. This means that any particular size group is made up of many elements. There are those that entered at a relatively small size and have experienced natural and fishing mortalities for a considerable length of time. There are others that have entered the fishery at almost the size at which they were caught and hence have only been depleted by natural mortality during their lives. Other shrimp enter the fishing grounds at intermediate sizes between these two extremes.

We need to know more about the relative numbers of various sized shrimp that enter the fishery in order that corrections can be applied to data obtained from landings and sampling. In the meantime, it will be difficult to apply even such relatively simple techniques as those suggested for other fisheries. One of these is given by Carlander (1959).

An additional complication for this problem is the fact that shrimp of a smaller size are shown by Ingle, *et al.* (1959) and Iversen. *et al.* (1960), to enter the fishery in greater numbers seasonally

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Promote Your Product or Lose Your Market

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I WOULD LIKE TO DEAL here briefly with one important part of the fishing industry's job—to sell its production profitably and the role of industry-backed promotion and advertising in doing this. The battle for the consumers' food dollar is a battle of advertising, promotion and new products. Twenty-four new products a day are presented to chain buyers to add to their more than 5,000 items in a super market. In 1959, sales in the United States rose to an all-time high of $78.8 billion for food and drink—about 24c out of every dollar of disposable consumer income. To spark this sales increase, the food manufacturing industry increased advertising expenditures from $320,000,000 in 1947 to a whopping $759,000,000 in 1959. It is worthy of note that many of the food companies showing the greatest sales growth and the best profits also showed the greatest expenditures for advertising.

No figures showing the amount spent for advertising by fish and seafood

processing companies is available (none were listed in Advertising Age's 1959 list of 100 top food advertisers). Of the total measured advertising (magazines, newspapers, TV and radio) expenditures by the combined meat, fish and poultry industries amounting to $22,258,000 in 1959, I am sure that everyone knows that only a small fraction of this amount was for fish and seafood advertising. But our advertising effort in the seafood industry is improving. More fish processing companies are finding that good advertising programs are sound investments for both the present return and for the future. As this fact becomes more generally a fact of business life, more seafood companies will turn to advertising to increase sales and profits rather than to depend on low prices to move the product. As these advertisers sell more products through advertising, the progress of the fish and seafood industry will move along with it.

For the balance of the seafood industry to wait for individual companies to do the entire promotion and advertising job will not protect the industry's stake in the fiercely competitive food business. Even with such strong brand advertisers as Maxwell House, Chase and Sanborn and many others, the Pan American Coffee Bureau spent $441,000 in 1959 in promoting the sale of coffee in magazines and newspapers. There is a real need for strong industry-wide advertising and promotional support by the fish and seafood industry and the industry has made a good start at the job.

A brief look at the advertising expenditures of other food industry trade associations show us the kind of competition we face in industry-wide programs. Here are a few of the top advertising trade associations and their 1959 expenditures in Measured Media Advertising (magazines, radio, TV and newspapers):

Florida Citrus Commission	$5,328,000
American Dairy Association	3,866,000
Sunkist Growers Association	2,272,000
American Sheep Producers Council	658,000

All told, 31 leading food associations spent $18,542,000, not including trade publicity, industry point of sale materials, or other promotional activities.

The funds for these programs are usually raised by assessments against production by member companies—per box of oranges, per 100 pounds of milk, etc. A good example of the effectiveness of this joint advertising effort occurred last fall in a Florida Citrus Commission campaign, supported by 22 producers of orange concentrate, which spent $3,359,000 in a September thru December advertising and promotional campaign to bolster what looked like a bad season because of heavy production. Result—sales up 31 per cent over the corresponding period in 1958. In the past, many efforts have been made in the seafood industry to get industry-backed advertising programs going. Some of these efforts have succeeded, at least for short periods of time, but many failed as the philosophy of "price-selling" overcame "product-selling." In times of oversupply and low prices, firms decided that advertising costs offered the most visible targets for cost-cutting and programs folded. In such times, as shown by the Florida Citrus Commission program last fall, advertising increases can help the profit picture.

The past decade has seen some solid progress in industry programs for advertising and promoting the sale of fish and seafoods. During this time the

joint program of publicity and promotion supported by United States National Fisheries Institute members, by their Canadian counterpart, the Fisheries Council of Canada and by Norway fish fillet producers, has spent about $60,000 per year, primarily in promotional and publicity activities with excellent results. In 1955, "Fish 'n Seafood Parade," an industry-backed fall sales promotion, was started on a $5,000 budget. This promotion has grown to a $25,000 annual budget and genuine success. In 1959, a similar Lenten promotion, "It's Fish 'n Seafood Time," was started with a $15,000 budget. This too, filled a big promotional need and efforts are being made to increase its budget. What are the results of these expenditures?

In the basic joint advertising and publicity program carried on through NFI, in "Fish 'n Seafood Parade" and in the new Lenten promotion about $90,000 was spent in 1959. Most of these funds went to publicity and sales promotion with small amounts to trade publication advertising. A check of the newspaper and magazine articles on fish and seafoods and the TV and radio time resulting directly from recipes, photographs and other promotional materials furnished by the industry program indicated that space and time worth almost $6,000,000 resulted from industry efforts—quite a return! Add to this the important support of the Bureau of Commercial Fisheries in making the industry programs pay off by field marketing help and the benefits mount up. Nor are the above programs the only seafood industry-sponsored programs operating. For ten years the Shrimp Association of the Americas, backed by shrimp producers of Texas, Florida, Mexico, and more recently El Salvador and Panama, have carried on an excellent program of advertising and sales promotion, spending over $50,000 a year. This year saw the start of a similar program supported by the National Shrimp Breaders' Association—an additional $35,000 per year. All this is good and certainly is helping the frozen fish and shrimp industries to do a better marketing job for its products, but is it enough in the face of increased competition from other food industries? Many industry people seriously concerned with the future think it is not enough—there are not sufficient funds for real consumer advertising and are working to expand these programs.

The seafood industry has come a long way in its product technology since World War II. Freezing now makes it possible to deliver fine quality fish or shrimp to Bismarck, North Dakota, and other places far from the sea. The seafood processing industry has developed many fine new products and will develop more, but there is a real need for the industry to tell its story of delicious protein food, low in fats and rich in vitamins and minerals. Its products have real romance in their harvesting and people want to know more about them. This is one of the reasons we get so much product publicity for our money, but if we are to gain the share of market our products deserve—yes, if we are to even hold our present place, we must increase our industry-sponsored advertising and promotional programs.

A Report on Federal Programs of Financial Aid to Commercial Fisheries

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Three programs of financial assistance aimed at upgrading the fishing fleets are now administered by the Bureau of Commercial Fisheries. These are:

1. The Fisheries Loan Fund authorized by the Fish and Wildlife Act of 1956 (This fund will cease to exist on June 30, 1965);
2. The Fishing Vessel Mortgage Insurance Program authorized by Title XI of the Merchant Marine Act of 1936, as amended, which function was transferred to the Department of the Interior pursuant to provisions of the Fish and Wildlife Act of 1956 (No time limit on program);
3. The Fishing Vessel Construction Subsidy Program authorized by Public Law 86-516, enacted June 12, 1960 (3-year program).

Singly, or combined, these aid programs are not a cure-all for the troubles of our fisheries. Each program is limited in its objective. But they are a step in the direction of improvement of our fishing fleets.

The aim of the mortgage insurance and subsidy programs is to encourage the construction of modern new vessels.

The Fisheries Loan Fund Program provides for new vessel construction only to replace vessels lost to the fleet through sinking, destruction, or obsolescence. But loans from this fund may also be made for other purposes. Its broad objective is to provide financial assistance, otherwise unavailable on reasonable terms, which will aid the commercial fishing industry to bring about a general upgrading of the condition of both fishing vessels and fishing gear, thereby contributing to more efficient and profitable fishing operations.

These efforts of Congress toward alleviating the depressed condition of our fisheries grew from a recognition of the rising danger to the nation from the threatened loss of our production potential and the possibility that the fisheries would be unable to provide vessels for defense purposes in the event of war or a national emergency. For several years beginning about 1950, vessel owners, dealers, and processors had made pleas to the Tariff Commission, to the President, and to Congress for protection or aid because a rising flood of imports was depressing prices and taking over a larger and larger share of their market as the United States became the largest importer of fisheries products in the world. Other economic factors were also incurring costs and decreasing returns to the fishermen. The American fisheries had seriously deteriorated during the past several years while foreign fisheries, benefitted in many cases by generous Government subsidies and loans, were flourishing and expanding. Much of the foreign fleet expansion was aimed at supplying American markets. Lower costs of building and operating foreign vessels, in addition to the direct financial aid from their Governments, gave foreign fisheries a decided competitive advantage

in our markets. Foreign products moved in to fill the supply gap needed to keep pace with the demands of our growing population. Their lower costs permitted profitable sales at price levels that reduced the operations of American vessels to subsistence levels. Not only could our vessel owners no longer liquidate their obligations in an orderly manner, but their debts rose as operating losses mounted. Maintenance was neglected, mortgage payments could not be met, and vessels were tied up for lack of funds or credit to provide for trip expenses. Foreclosures became commonplace. Some of our key fisheries had reached a state of stagnation by 1956.

At this stage in the history of our fisheries the Fisheries Loan Fund Program came to the rescue. The full benefit of the Fisheries Loan Fund is a story that will never be known. We do know, however, that several hundred vessel owners who had been in dire distress put their vessels in good condition, refinanced their mortgages and other debts on terms they could meet, and returned to a profitable base of operations. Hundreds of other vessel owners had already lost their vessels or reached a state where it was too late to take advantage of this assistance.

The Secretary of the Interior is authorized to make loans for financing and refinancing of operations, maintenance, replacement, repair and equipment of fishing gear and vessels, and for research into the basic problems of fisheries. A basic requirement of the Act is that no loan can be made if the assistance applied for is available on reasonable terms from other sources. Shore plants and auxiliary vessels, such as packers or fish freighters, are not eligible. This is a soft loan program in the sense that longer maturities and lower interest rates are offered as compared to commercial loans. But the Act clearly shows the intent of Congress that the loans be collectible as to principal and interest. Accordingly, each loan must be adequately secured.

The proposed collateral for a loan must be of such a nature that, when considered with the integrity and ability of the management, and the applicant's past and prospective earnings, repayment of the loan will be reasonably assured. These qualifications are substantiated by field investigations. Bureau field representatives cover the vessel and fishery aspects in all cases and the financial investigation where the application is for no more than $10,000. If the application is for more than $10,000, the Small Business Administration conducts the financial investigation and reports thereon to the Bureau.

Generally, a preferred ship mortgage on the vessel is the only collateral required to secure the note signed by the applicant and wife. If the applicant is a partnership, all members of the partnership and their spouses sign the note. If the applicant is a corporation, the officers, managers, and principal shareholders must guarantee the note. The reason for this is that the fishing vessel is usually the only asset of a small corporation which exists only to avoid personal liability of the owner or owners.

Hull insurance is required to safeguard the collateral vessel, and usually property and indemnity insurance is required to assure ability of the applicant to continue in operation in the event of a serious liability claim. The latter insurance may be waived by the Secretary at his discretion.

Loans cannot legally be made for longer than 10 years. The remaining useful life of the vessel, the engine, and the equipment must be given due consideration in evaluating a loan application. At the same time, ability of the applicant to

repay the loan within such period must also be carefully evaluated. While the age and health of an applicant are given consideration, no age limit is imposed.

Repayments are usually based upon the customs that have prevailed in the particular fishery. In some cases, payments are made after the completion of each fishing trip and calculated as a percentage of the vessel's share with the minimum requirement that a definite percentage of the loan must be repaid each year. Fixed periodical installments of principal plus interest are usually provided where payments are spaced more than one month apart. If monthly payments are stipulated in the note, they may be computed so that a uniform installment, including interest and principal, will amortize the loan.

Collections of principal and interest are deposited in the Fund and are available for additional loans. Expenses to the Government are paid out of the Fund under limitations set by the Bureau of the Budget. It is contemplated that the program will during its life be self supporting and that the Treasury will recapture the entire amount of the capital advanced for its operation, after administrative costs and losses have been provided for. Of course, it will not be possible to collect every loan. Some foreclosures are inevitable. Some losses have been sustained and there will undoubtedly be others. But the loss rate so far compares favorably with that of banks which have made fisheries loans. Nearly one-half of the applications received have not met the minimum requirements and therefore could not be approved.

The loan program has now been in operation for about four years. Loans have been made in all fishing areas of the United States, including Alaska and Hawaii. It has provided 46 new replacement vessels, replaced 90 worn-out engines with new ones, enabled owners to rebuild 121 vessels and re-equip 119. Fifteen tuna clippers have been converted to purse seiners. One hundred and sixty-seven mortgages on vessels have been refinanced, and 162 loans were used in part to refinance debts constituting maritime liens. From inception of the program in 1956 through September 30, 1960, 435 loans have been approved for a total of $10.5 million. The geographical distribution is as follows: New England and Middle Atlantic area 130 loans for $3.8 million, California 71 loans for $3.3 million, South Atlantic and Gulf 64 loans for $1.6 million, Pacific Northwest 89 loans for $1.2 million, other areas 81 loans for $0.6 million.

Although the Fishing Vessel Mortgage Insurance Program was authorized by the Merchant Marine Act of 1936, as amended, the authority to insure mortgages for the construction, reconstruction, or reconditioning of fishing vessels was exercised in only a few instances by the Maritime Administration in all the years since enactment of the law. Prospective applicants found it impractical if not impossible to meet the requirements imposed by its regulations. The Maritime Administration policies centered on the Merchant Marine and no attempt was made to provide service for fisheries. When this function was transferred to the Department of the Interior on March 22, 1958, no provision was made on paying claims in the event they should exceed the amount in the revolving fund generated by fees and insurance premiums. Consequently, the Department was unable to put the program into effect until enabling legislation was enacted.

Public Law 86-577, signed July 5, 1960, gives the Secretary authority to borrow funds from the Treasury; if necessary, to pay claims if the revolving fund should at any time not have a sufficient balance. To some extent the program is

similar to FHA. Mortgage money is supplied by commercial lenders. The applicant must invest not less than 25 per cent of the cost of the vessel. The mortgage for not more than 75 per cent of the cost, not including any Governmen subsidy payment, may be insured by the Department. Maturity must not be longer than 15 years, or the useful life of the vessel whichever is less. Premium rates are one (1%) per cent of the face of the mortgage if the mortgage covers more than 50 per cent of the cost, or three-fourths (¾%) of one per cent if the mortgage covers 50 per cent or less of the cost. Mortgages already in existence cannot be insured. Applications must be filed at least 90 days before construction is to begin in order to give the Secretary enough time to make a full investigation and do the other things required.

All necessary preparations were completed recently and field representatives have been instructed in the mechanics of the program. While it is too early to assess the benefits to the fishing industry, the widespread interest already expressed in the mortgage insurance program leads us to believe this assistance will prove to be an effective aid in restoring the fishing fleets.

The Fishing Vessel Construction Subsidy Program, authorized by the Act of June 12, 1960, is the newest of the federal financial assistance programs. It is designed for the sole purpose of encouraging construction of new vessels to maintain fleets in fisheries that are injured or face threat of injury by reason of increased imports of like or competing fishery products. A fishery is automatically eligible where the Tariff Commission has recommended relief under the escape clause provision of the Trade Agreements Extension Act of 1951, as amended (65 Stat. 74), but relief has been denied under Section 7 (c) of such Act. In all other cases eligibility depends upon a finding by the Secretary of the Interior that a fishery is injured or threatened with injury by reason of increased imports of directly competitive fish or shellfish products. A positive or negative finding will be made by the Secretary upon request of an applicant supported by reasonable evidence. Such a finding will not be made however until interested parties are given 30 days, following publication of notice in the Federal Register, to submit written statements in support of or in opposition to the allegations of the applicant. The finding will then be published in the Federal Register.

Additional eligibility requirements apply to the applicant and to the proposed vessel. These include evidence or assurance that the vessel (a) will be suitable for defense purposes, (b) will be of modern design which will tend to upgrade the fleet, (c) will not operate in a fishery which the Secretary deems to have sufficient vessels to economically harvest either the maximum sustained yield or maximum amount which can be marketed in an orderly manner, (d) will deliver its catch to United States ports, (e) will employ in its operation only citizens of the United States or aliens legally domiciled in the United States, and (f) will be documented in the United States. Moreover, the Secretary must determine that the applicant possesses the ability, experience, resources, and other qualifications necessary to enable him to operate and maintain the proposed new fishing vessel. At present, the only fishery automatically eligible is the New England groundfish fishery which has been denied relief after favorable recommendations by the Tariff Commission.

A vessel to be deemed as operating in a particular fishery must take not less than 51 per cent of its annual catch from that fishery. If a vessel that has

received a subsidy is diverted to another fishery or other use, a part of the subsidy must be returned to the Government as provided in the subsidy contract.

A subsidy under this Act may not exceed one-third the cost of construction in a U. S. shipyard, or the difference between such cost and the cost of constructing a similar vessel in a foreign shipyard, whichever is less. The Act authorized an appropriation of $2.5 million a year and provided that no application could be accepted more than 3 years after the effective date of the Act. However, Congress actually appropriated only $750,000 for the current fiscal year ending June 30, 1961.

All necessary preparations have been completed and field offices have been supplied with forms, printed material, and instructions. Quite a bit of interest has been evidenced by inquiries received to date.

Foreign fisheries exert a tremendous influence in the markets of the United States. In 1959 our imports reached a total of $366 million. These enormous imports came from countries whose Governments have been actively aiding their fisheries for many years with loans and grants.

With them, as with us, investment capital through ordinary commercial channels is restrained at levels below that required for maintenance, replacements, modernization, or expansion of the fishing fleets. All major fish producing nations have set up programs involving the use of public funds to provide capital under conditions of special advantage to their fishing industries.

Canada, our largest supplier, has a number of financial aid programs involving loans, grants, or loan insurance. One plan provides grants of $165 per gross ton for building trawlers or longliners. Others provide for loans to acquire new vessels, grants to pay part of the interest on commercial loans or on life insurance premiums required on private loans for the construction of vessels, purchase of engines, equipment, and gear.

Japan, a major supplier, provides loans up to 80 per cent of the cost of construction or purchase of vessels and gear. Maturities may be 10 years with no repayment during the first two years.

Belgium grants loans up to 70 per cent of the cost of a vessel or its improvement.

Denmark provides loans up to two-thirds of the cost of acquiring new vessels, and one-half the cost of used vessels.

France provides loans up to 75 per cent of the cost for purchasing or construction of new vessels or acquisition of engines or electronic equipment. Maturities are up to 10 years.

West Germany loans up to 75 per cent for construction of new vessels, and acquisition of engines, or for repairs and modernization. Maturity is up to 15 years and interest is three per cent.

The United Kingdom provides grants up to 30 per cent of the cost of new vessels or engines and loans up to 60 per cent with maturities of 15 years.

Descriptive leaflets have been prepared for each of these programs.

Fishery Leaflet 477—Fisheries Loans
Fishery Leaflet 499—Mortgage Insurance
Fishery Leaflet 503—Subsidies

Field Offices of the Branch of Loans and Grants, Bureau of Commercial Fisheries, are equipped to give information and assistance to interested parties.

The addresses are:

408 Atlantic Avenue, Boston 10, Massachusetts

P. O. Box 6245, St. Petersburg Beach, Florida

101 Seaside Avenue, Terminal Island, California

6116 Arcade Building, Seattle 1, Washington

P. O. Box 2481, Juneau, Alaska

2570 Dole Street, Honolulu, Hawaii

TUESDAY—NOVEMBER 15

Chairman—LAWRENCE I. CLARKE, *President, Atlantic Processing Company, Amagansett, New York*

Potential for Fish Solubles — Liquid Fish in the Fertilizer Industry

ROY C. STEVENS
U.S. Bureau of Commercial Fisheries
Jacksonville, Florida

THE ORIGIN OF THE USE OF FISH as a fertilizer material is lost in antiquity. The practice has continued through the ages until in recent years, when it has largely been discontinued due to the relatively high cost of fish products for this purpose as compared to other materials available.

However, developments bringing about a depressed condition in the fish meal market within the past year and a half have rekindled the interest of the industrial fish industry and of the Bureau of Commercial Fisheries in the possibility of fishery products again entering this field. First, the production of menhaden in 1959 reached an all-time high of 2.18 billion pounds compared with 1.5 billion in 1958; second, the poultry market, which is by far the major outlet for fish meal, suffered a serious decline in 1959 at the time that our production of fish meal was the highest; third, imports of fish meal began to flood our markets at prices against which our producers could scarcely compete, particularly in a depressed market. This continuing situation, coupled with the intensified search for cheaper substitutes for fish meal as a source of the unknown growth factor in poultry feeding, has pointed up the need for research into other uses for industrial fish.

In one of our contacts a few months ago, it was learned that two grove service companies in Central Florida were experimenting with fish solubles as a fertilizer for citrus groves. We were told that the material had been found to be particularly effective with trees in high, sandy soil; that it had the effect of "binding" the soil to retard the leaching of nutrients and that it was providing excellent growth in young trees and good "greening" in adult trees. These claims were supported by the growers when they were visited a short time later, although they had not yet had time to determine the effect of the material on fruit production. One of their most enthusiastic claims was that the material brought about a restoration of trees that had become badly "run down" despite regular applications of standard fertilizers. They were using fish solubles at the 25 per cent solids level in quantities of about one ton per acre.

Feeling that we had something worth investigating further, we contacted different specialists in the fields of fertilizer research and plant nutrition to see what may have been done in the way of research on fish materials and to determine the possibilities for future research. In each instance, we were told

that fish was considered simply as one source of organic nitrogen. It was also their belief that, in most applications, the cheaper inorganic nitrogen was just as effective as organic. Research had proved conclusively that a citrus tree, for instance, could absorb and store, in one application of inorganic nitrogen, all of the tree's requirement of that element for an entire year. It was agreed, however, that the slower-releasing organic nitrogen provided some advantage in other applications. The trace elements contained in fish products were considered relatively unimportant inasmuch as most soils in this country are not deficient in these elements. Where such deficiencies do occur, the need, they said, can be supplied more cheaply by direct application. We stated that the results apparently being obtained through the use of fish solubles in Florida citrus groves and the many reports of outstanding results achieved with fish materials elsewhere, led us to suspect that fish may contain a factor or factors for plant growth and fruit production similar to that provided by the "unknown growth factor" for poultry growth and egg production. These results, we felt, could not be explained simply on the basis of nitrogen-phosphate-potassium content alone; firstly, because the N-P-K content of fish is relatively low as compared with those of most fertilizer mixes; and secondly, because in the tests previously mentioned noticeable improvement was observed where the solubles material was used as a supplement to standard mixes considered fully adequate in the essential elements. After considerable discussion, the researchers conceded that fish materials could possibly contain some factor or factors capable of providing a bonus or tonic effect beyond that to be expected from their basic elemental content.

It was obvious at this point that research would have to be conducted to determine whether the special effect theory is valid. We have already made arrangements for part of this research. The research director of the USDA Agricultural Experiment Station in Orlando has agreed to conduct small-scale experiments with citrus trees over the next two to four years using fish solubles and liquid fish to be supplied by a Florida menhaden producer. The owner of a liquid fertilizer manufacturing company in Kentucky has also agreed to conduct experiments on one to five acres of field crops if samples of material are provided. The industry is grateful for these offers of assistance and will certainly be taking advantages of them. However, the research with citrus trees will, of necessity, take from two to five years before any conclusive results can be obtained. The research in Kentucky will, likewise, require a minimum of two years. In addition, it will be conducted by a private concern and we have no guarantees as to its comprehensiveness or impartiality. These programs are fine, but they are not enough.

What is needed is a three-pronged attack on the problem—1: The industrial fish industry needs help *now!* A crash program of research should be contracted with a federal, state, or university organization to study the effectiveness of fish materials in truck crops in an area where three or four crops are possible within a single year. The results of thorough, unbiased tests by such an organization would be readily accepted by the fertilizer industry and by agriculture. 2: Concurrent with this crash program, and on a two-to four-year basis, modest-scale research should be conducted with various field and orchard crops. 3: If and when positive results are indicated in the crash program, large-scale tests should then be undertaken to determine the factors involved in actual commercial use of these products. These tests should be conducted using both fish solubles and

liquid fish. Solubles are a byproduct of the manufacture of fish meal, whereas liquid fish is a product prepared directly from the raw fish by controlled enzymatic hydrolysis. Both products are relatively inexpensive, although neither can presently compete with other sources of nitrogen on a per unit basis. Price, however, is a relative term, and if these materials should prove effective, they will demand a price commensurate with their value in increased production and growth.

The reasons for including liquid fish in this program are these: 1: If and when the unknown growth factor has been isolated, it is quite possible that it can be synthesized or derived from some source cheaper than fish meal. Another use or another market would then have to be found for industrial fish. 2: Liquid fish is simple and inexpensive to produce. The high cost of firing dryers is reduced materially and the byproduct oil can still be removed. 3: In the event that research should prove liquid fish to be an effective fertilizer material, it is possible that fish meal producers may realize greater profits by converting to liquid fish production than by continuing in meal production.

It is the opinion of many that a balanced fertilizer mix using liquid fish or fish solubles as the base will provide bonus effects in plant nutrition and production and that such a fertilizer can be produced at a price that will be competitive with other high-grade fertilizers available on the market. Only comprehensive, unbiased, fully-controlled research will give us the once-and-for-all answer.

Effect of the 1960 Law of the Sea Conference on the High Seas Fisheries

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The Resources Committee
San Diego, California

I LAST ADDRESSED THIS INSTITUTE on the subject of the Law of the Sea and High Seas Fisheries Management with a paper written in the late fall of 1955 (Chapman, 1955).

Nineteen fifty-five had been an eventful year for this subject. The General Assembly of the United Nations had ordered convened a Specialized Conference on the "Conservation of the Living Resources of the Sea" so that the International Law Commission and it would have the benefit of the advice of the fishery experts of the world on these technical aspects of the Law of the Sea, and it had instructed the Commission to have a final report on the whole subject of the Law of the Sea ready for the General Assembly at its 1956 fall session.

The specialized conference had taken place in Rome on schedule in April of 1955. Forty-five nations had been represented by voting delegations and another six had sent observers. All of the International Fisheries Commissions in the world and other such expert bodies had been represented by their top scientists. The Conference had been very successful and had presented a competent, agreed report on the subject to the International Law Commission, the General Assembly, and the member governments.

Working on the basis of this report from the Rome Conference the International Law Commission had, at its 1955 session in Geneva, compressed the principles of this report into a set of ten fishery articles and incorporated these articles into a comprehensive report on all aspects of the Law of the Sea which it had submitted to the member governments for their comments preparatory to the Commission's task of finalizing its report for the General Assembly at its 1956 session. Also in 1955 there had been a conference on fisheries among the United States, Chile, Ecuador and Peru. This latter conference had reached no agreement but it had succeeded in clearing the air a good deal in what had been a most vexing problem among these otherwise friendly powers.

At the end of 1955 it had appeared that the world was pretty well agreed as to what fishery conservation was, as to the principle that all nations were responsible for seeing that their nationals did not overfish any high seas resource, and as to the methods by which conservation of the living resources of the high seas could be obtained by peaceful means.

The two key questions which had not been solved at the end of 1955 were (1) what was the breadth of the territorial sea, and (2) what was the proper jurisdiction of the coastal state over fisheries lying in the high seas off its coast. Even on these two vexing problems considerable progress had been made.

It seemed obvious at the end of 1955 that the consensus of world opinion was that the proper breadth of the territorial sea lay between three and twelve marine miles and that the rest of the ocean was high seas.

On the other problem it appeared that the coastal state would be able to insure that the fishery resources off its coast would not be overfished by establishing its own regulations if necessary, but that any regulations it made to ensure this would not apply to fishermen of other countries except under carefully prescribed conditions that would not discriminate against the foreign fishermen, would have to be based upon appropriate scientific findings, and in the last analysis could be brought for compulsory arbitration before an impartial committee of experts chosen by the Secretary-General of the United Nations with expert advice as to their choice either from the head of the International Court of Justice or the Food and Agriculture Organization of the United Nations, or both.

Thus 1955 seemed to have produced a quite considerable progress on these problems of governing the sea which had been vexing mankind since the first sail was hoisted on the first mast, and which had been growing particularly more irritating to the body politic in the years since the end of World War II.

But all of these conclusions were tentative at the end of 1955. There were several key meetings to be held in 1956 which would perhaps determine whether these tentative conclusions would be incorporated in the body of practice governing the relations between sovereign nations, or whether they would be abandoned. There were four such meetings scheduled for 1956 when I last reported to the Institute: (1) The Inter-American Council of Jurists at Mexico City in January, (2) The specialized conference on the Conservation of the Living Resources of the Sea to be held under the auspices of the Organization of American States at Ciudad Trujillo in the early spring, (3) The eighth session of the International Law Commission to be held in Geneva in the late spring, and (4) The eleventh session of the General Assembly of the United Nations to be held in New York in the fall. Any or all of these could blow the progress made during 1955 to smithereens.

During 1956 there also were to develop two additional crucially important forces bearing upon this already complex question of the Law of the Sea. Both had been latent but not much effective in 1955 and before; both came pretty well to full bloom before 1956 was over. These two factors were the world wide struggle between the Communists and the Free World (or, more properly speaking, between the Russian Empire and the rest of the world); and the struggle of the so-called Arab Nations to unite themselves into one working unit and to eradicate the new State of Israel.

The difference between three and twelve miles does not look very great when viewed from a deck at sea, but when viewed from a mahogany desk in the office of the Chief of Naval Operations either in the Pentagon or the Kremlin it is all the difference in the world. The task of the United States Navy, at the head of a federation of nations held together by the ocean and sea power, is to keep the lanes of communications among its elements as free as possible in peace as in war; the task of the Russian Navy, as the servant of a continental land power, is to hamper or even interdict sea travel among the elements of the naval confederation of the free world as much as possible not only in war, but also in peace if that is possible. Any broadening of the territorial sea would damage the defense potential of the free world and the ability of the United States to protect it; a broadening to twelve miles might favor the Russians to a critical degree. Both powers realized this.

During 1956 this essentially military argument was intruded into the Law of the Sea problem by both sides to a degree that was to make it the dominant factor in the coming years and prevent the complete solution of it. Furthermore this was to become a terrifying spectre to the United States fishermen. The military factor in the United States position on the Law of the Sea was to become so dominant that the United States would be prepared to trade away any or all of its fisheries rights in exchange for the requisite number of votes to nail down a narrow territorial sea.

The second factor—the controversy between Arab and Israeli—was for four years to give Russia an extra solid core of eleven or twelve votes for a 12 mile breadth of the territorial sea which, added to their own nine votes, would put them always within relatively easy reach of the necessary one-third of votes required to block the adoption of any substantive proposal.

Nineteen fifty-six started off badly by the adoption by a wide margin at the meeting of the Inter-American Council of Jurists in Mexico City of the so-called "Principles of Mexico" which, had it been adopted by the world community, would have led to complete chaos in the Law of the Sea by permitting each country to establish its own territorial sea, within very broad limits, and require the observance of it by other nations.

This victory by the broad territorial sea countries was very temporary, as is often the case when a motion is ram-rodded through an international meeting on emotional grounds. The very next motion at that meeting, in fact, was to refer this so-called "Principle of Mexico" as a background paper to the Specialized Conference on the Conservation of the Living Resources of the Sea to be held under the auspices of the Organization of American States at Ciudad Trujillo that spring. This was passed, the specialized conference only agreed that the nations of the Americas were disagreed on the Law of the Sea, and the so-called "Principle of Mexico" disappeared into the limbo of forgetfulness

where rest the mountains of background documents prepared for international conferences.

The International Law Commission met in Geneva in the spring of 1956. It amended its report of 1955 in many detailed respects in the light of comments it had received over the winter from the member governments. No major changes were made in it. If anything the Commission's final report to the General Assembly resulting from this 1956 session was a better, more polished, competent and satisfactory document than was its 1955 preliminary report.

But the ILC had been quite unable to reach agreement as between three and twelves miles for the breadth of the territorial sea. It quite properly viewed this as a political rather than a legal question and recommended that the General Assembly convene a Conference of Plenipotentiaries to act upon its whole report on the Law of the Sea and settle these political as well as legal and other questions in the proper way, by a Council of the Nations.

The General Assembly considered this subject extensively at its eleventh session that winter and finally on February 21, 1957 did what the ILC had recommended. It decided "in accordance with the recommendation contained in paragraph 28 of the report of the International Law Commission covering the work of its eighth session, that an international conference of plenipotentiaries should be convoked to examine the law of the sea, taking account not only of legal, but also of technical, biological, economic and political aspects of the problem, and to embody the results of its work in one or more international conventions or such other instruments as it may deem appropriate."

Thus the first Geneva Conference on the Law of the Sea came into being on February 24, 1958 and lasted until April 27, 1958. Eighty-six countries were represented by plenipotentiary delegates. Press accounts of this conference would lead one to think it was more or less a failure. In my humble opinion no conference so representative of all the peoples of the world had ever accomplished so much before or since. As a matter of fact there had never before been a conference of plenipotentiaries so fully representative of the peoples of the world. A full 30 per cent of the nations represented and voting had not existed as sovereign nations at the end of World War II.

The Conference was quickly divided for its work into five main committees: (1) Territorial Sea and Contiguous Zone; (2) High Seas: General Regime; (3) High Seas: Fishing, Conservation of Living Resources; (4) Continental Shelf; and (5) Question of Free Access to the Sea of Land-locked Countries. By the end of the conference each of the first four committees had adopted a report in the form of a convention to be opened for signature by the nations and the Conference had adopted all four conventions, an optional protocol and a series of pertinent resolutions. The four substantive Conventions comprehended all aspects of the complex Law of the Sea, upon which agreement was had on all except two points.

As a matter of fact the degree of unanimity reached by the nations in adopting these Conventions was nothing short of remarkable. The Convention on the Territorial Sea and the Contiguous Zone was adopted by a vote of 61 to 0 with 2 abstentions. The Convention on the High Seas was adopted by a vote of 65 to 0 with 1 abstention. The Convention on Fishing and Conservation of the Living Resources of the High Seas was adopted by a vote of 45 to 1 with 18 abstentions. And, finally, the Convention on the Continental Shelf was adopted by a vote of 57 to 3 with 8 abstentions. It would be hard to "rack up" a better

score than this on four subjects all of which were so complex and all of which contained highly controversial elements.

While each of these four conventions contained elements that were important to us fishermen of the world it was the third, "Convention on Fishing and Conservation of the Living Resources of the High Seas," that was most important to us. This Convention was remarkable on at least two grounds: (1) that it contained so much that was not the codification of existing practice but was instead legislative in effect, and (2) that after these two months of the most bitter sort of wrangling and acrid discussion in Committee Three there was almost unanimous agreement upon the resultant convention. Among the eighteen abstaining nations were the nine captive Russian votes and the Russians very plainly stated that they were agreeable to the Convention but could not vote in favor of the compulsory arbitration phase of it, not because they were against arbitration of fishery disputes but because they were opposed to compulsory arbitration of anything on principle. The others who abstained presumably did so on grounds that would not bear public examination because they did not comment upon their action.

The Convention as it was worked out was a straightforward business deal between the largely non-fishing, so-called "coastal" states and the large fishing states, each group of which had enough votes to have blocked any action that the other side would have wanted to take that was against its interest.

In the first place conservation was defined as "the aggregate of the measures rendering possible the optimum sustainable yield from those resources so as to secure a maximum supply of food and other marine products."

This definition itself was a compromise and a momentous decision. For the first time, in essence, the world had agreed that underfishing was as wasteful and against public interest as was overfishing.

Having defined conservation the Convention then said that all States had the duty to ensure that its nationals did not overfish any high sea resource but that subject to this condition, and others which may have been agreed to, the nationals of all nations had a right to engage freely in fishing on the high seas.

The remainder of the 22 article Convention comprised the business deal. The so-called coastal States were given the power to force upon the fishing States adequate conservation in fisheries in the high seas off their coast, even to the extent of establishing regulations over the fishery unilaterally which would apply to all fishermen in the area. This was balanced by the necessary qualifications that such regulations would not be discriminatory against foreign fishermen, would be bonafidely necessary for conservation purposes, and would be based on appropriate scientific findings.

To keep everybody honest, and to make the deal palatable to both sides, everybody was given the right to challenge anybody else either on the point that they were overfishing or on the point that they were being unjustly regulated in fishing. Such a challenge, under well-restricted criteria cutting both ways, was ultimately referable to an impartial board of experts for their decision on the merits of the case if the parties to the dispute could not reach agreement by any other peaceful means. The findings of this board were final and had to be abided by by both disputants.

This Convention did not by any means provide machinery capable of resolving all of the fishery disputes in the world. It only said that it is in the interest of mankind generally that conditions will be established which will

permit the maximum sustainable production of food and other living products from the sea, and set out the rules under which this could be accomplished by preventing overfishing and by preventing interference by foreign governments of fishermen except those necessary to prevent overfishing.

Economic competition among nations for fisheries was not touched upon by this convention. A typical example of this sort of thing, which is the basis of several current fishery disputes in the world, is where one nation is not as competent fishery-wise as another and wishes to hamper the fishermen of the more efficient nation by regulation so as to give its own inefficient fishermen an advantage in the market place which might overcome their margin of inefficiency. Although these economic problems are not soluble by this convention the document does prevent the aggressor nation from moving against the efficient nation under the guise of conservation. It can be hauled into a competent court for doing that.

Although it is not the stated subject of my talk I have dwelt upon this 1958 convention at some length because it describes the current situation.

The two things upon which the 1958 Conference on the Law of the Sea was unable to agree were just what the Rome Conference and the International Law Commission had not been able to agree upon in 1955: (1) the breadth of the territorial sea, and (2) the extent of the jurisdiction by the coastal state over fisheries lying in the high seas contiguous to its territorial sea. These are, of course, the meat of the coconut. If you don't know what the breadth of the territorial sea is you don't know where the high seas begins that you are free to fish upon. Also if the coastal state does have some special rights, other than those needed to ensure conservation, over the high seas fishery close to its shore the foreign fisherman is liable to be subjected to a good deal of harassment unless he knows what those rights are and in what area of the sea they can be applied against him.

Not having been able to resolve these two key problems, and having run out of time as well as patience (and as the event turned out, having agreed upon as much on these subjects as the nations were capable of agreeing upon at this stage of history) the Conference, after adopting these four conventions, an optional protocol, and several pertinent resolutions, resolved at the end "to request the General Assembly of the United Nations to study, at its thirteenth session, the advisability of convening a second international conference of plenipotentiaries for the further consideration of the questions left unsettled by the present Conference."

The General Assembly did study this suggestion at its thirteenth session and after long debate adopted, on December 10, 1958, a new resolution calling for a Second Conference of Plenipotentiaries on the Law of the Sea to consider just two questions: (1) the breadth of the territorial sea, and (2) the extent of fishery limits. This conference convened on schedule in Geneva on March 17, 1960, and ran until April 27.

The issues at this conference were so simple and straightforward that there was no use in splitting the Conference up into separate Committees to consider them, as was done at the 1958 Conference. Instead the procedure was adopted of adjourning the Conference to a single "Committee of the Whole." The purpose of this device was to give flexibility to the Conference. Nothing of a substantive nature could be adopted by the Conference except by a two-thirds majority of those present and voting, but in the "Committee of the Whole"

proposals could be adopted by a simple majority provisionally. This would then have to pass the two-thirds test later in the plenary sessions of the Conference, but it would permit a greater variety of ideas and compromises to be tried out than if all the work of the Conference were conducted within the straight-jacket of the two-third rule.

It will not be my purpose to discuss the happenings during this exciting, almost frenetic, conference. The upshot of the Conference was that it did not adopt anything on the subjects it was called to consider. The only thing it adopted was an inconsequential resolution suggesting to the General Assembly that it consider recommending larger technical assistance programs in fisheries for the under developed countries. However, what did not happen at the Conference was almost as important to the fish business of the world as what did happen, so I will refer briefly to this and its causes.

One thing that needs to be kept in mind is that Russia, while working consistently for the twelve mile territorial sea on military grounds, has just as consistently worked against any controls outside twelve miles for fisheries except for bonafide conservation reasons. This dichotomy of purpose has been evidenced on every vote on this issue that has come up since the Rome Conference in 1955. Russia is undertaking a world-wide expansion of its high sea fisheries and does not want them impeded from going anywhere on the high seas to fish.

The second thing to be kept in mind was that the United States wanted a narrow territorial sea on military grounds and was determined to get this come what may. To it the fishing rights it had on the high seas were purely secondary to the military issue and were useful to it chiefly as bargaining material with which to win votes for the narrow territorial sea.

The third thing to keep in mind was that the United States could not give its fishing rights on the high seas away for votes without the concurrence of Western European votes. In Western Europe were 18 votes and these, despite the NATO military relationship, were in many cases more interested in the fishery argument than in the military argument.

The fourth thing to think about was the solid bloc of Arab votes which were just against Israel and had no interest of consequence in fish. They wished by a 12 mile limit to cut off access by Israel to the Red Sea and Indian Ocean through its southern port of Elat on the Gulf of Aqaba by closing the straits at Tirana.

The fifth thing to keep in mind was the driving urge in the United States and England to win a two-thirds majority for the narrow territorial sea. A number of the policy men in both countries had convinced themselves that if they did not win a two-thirds majority at this Conference for a narrow territorial sea the Russians would win the 12 mile territorial sea argument in a few years' time simply because all of the new countries coming into being would be 12 mile countries and enough others would join them to make the 12 mile limit the rule of law in the long run.

I may say that this same argument determined United States actions at the 1958 Conference as well as at the 1960 Conference, and in neither instance has this dread of a stampede to the 12 mile limit eventuated. But nevertheless this urgent fear in the United States and English views led to an almost complete subordination of the fishing interests of both in the ensuing actions.

One final thing needs to be kept in mind. In their driving urge to get a two-

thirds vote in favor of a narrow territorial sea toward the end of the 1958 Conference the United States and England had made a tactical error that was to have strategic, and perhaps tragic, consequences. They backed a compromise which would have given six miles of territorial sea to all countries plus six miles of special jurisdiction over fisheries additionally except where a country already had fishing rights in that outer six miles. This compromise became humorously referred to as the six plus six minus six formula. It lost in 1958.

While it lost, and the United States and England reverted to their pristine 3 mile position; they felt it quite impossible and unrealistic to go into the 1960 Conference with any position less than this. Accordingly they had weakened their military argument by agreeing to extend the territorial sea and thus voluntarily giving up the 3 mile limit *de facto*, while not gaining any votes by doing so. Then, and now, countries who would vote for a 6 mile limit, for the most part, would vote for a 3 mile limit with even greater ease.

Secondly by adopting this compromise in 1958 the two leading countries on the freedom of the seas had introduced, or admitted, the concept that exclusive fisheries jurisdiction and the territorial sea were not necessarily coterminous.

Eighty-eight voting countries showed up at Geneva in 1960. There are three ways to vote in United Nations matters — yes, no or abstain (or just not show up). The majorities are calculated just on the basis of the yeses and noes. Thus if all 88 countries vote either yes or no 30 votes would be a blocking third. If 1, 2, or 3 countries abstained 29 votes would be a blocking third. If 4 or 5 countries abstained 28 votes would be a blocking third.

It was generally conceded by all hands at the beginning of the 1960 Conference that Russia had 24 certain votes in favor of a 12 mile limit that she could hold against any compromise. These were the nine Russian plus satellite votes, plus the Arab bloc (which was not interested in fisheries), and plus a few Latin American votes. To this hard nut the Russians would only require to add 4, 5, or at most six votes to get a blocking third, and this did not look hard for them to do because there were at least a dozen other countries besides those who already had 12 miles or more of territorial sea incorporated in their domestic legislation or, for one reason or another, wanted a 12 mile limit.

In the final show down vote things did not work out exactly like this because of some exceedingly skillful and hard driving diplomatic activity by United States diplomats both in Geneva and at far flung points all over the world in the last few days of the Conference. But right up to the finish wire it looked like the United States had a more than Herculean job on its hands. Forty-five or fifty votes (a clear simple majority) it could get for a narrow territorial sea easily (even for a 3 mile limit). But to stretch this to a winning 58, 59, or 60 votes for two-thirds majority (depending on the number of absentions) looked to be beyond expectation.

While the military objective was taken as being the overwhelmingly most important goal, perhaps 40 votes at the Conference were strongly affected by the fishery issue and had relatively slight interest in the military issue. One of the key tasks was to give enough fish away to bring in the needed Latin American, African and Asian votes without estranging the European and Japanese fishery vote by giving too much fish away, as had been done in 1958. Seeking this compromise was the prime activity of the last days at the Conference.

This was finally done very nearly successfully by a compromise whose result, had it been put into practice, would have been directly contrary to the policies adopted by the nations in Rome and Geneva that had led to the nearly unanimous adoption of the Convention on Fishing in 1958. It would have been very damaging to all long-range fishermen in the world, had it been adopted, and contrary to the public interest of the world.

The United States and Canada had brought forward a compromise proposal in Committee (which finally ended up as L.11 in Plenary) which entitled a State to a six mile territorial sea plus a 6 mile zone of exclusive fishery jurisdiction. In the outer 6 mile zone countries who had fished there for the preceding five years could continue to do so for the next ten years. All substantive amendments to it had been voted down in Committee and it had won by a handsome simple majority of 43 in favor, 33 against, with 12 abstentions. The Russian 12 mile proposal, buttered up as favorably as possible, had lost in Committee by 36 in favor, 39 against and 13 abstentions. It would certainly not appear again in Plenary because it would lose votes instead of gain more. It did not appear again in the Conference.

The task now was to contrive another compromise to be added to the Canada-U. S. proposal which would pick up the necessary additional votes to win it a two-thirds majority in Plenary. This was done in a proposal (L.12) introduced finally by Brazil-Cuba-Uruguay as an amendment to the Canada-United States proposal. The key features of this amendment were paragraphs 6 and 8, which read as follow:

> "6. Notwithstanding the provisions of the preceding paragraphs but subject to the paragraphs below, the coastal State has the faculty of claiming preferential fishing rights in any area of the high seas adjacent to its exclusive fishing zone when it is scientifically established that a special situation or condition makes the exploitation of the living resources of the high seas in that area of fundamental importance to the economic development of the coastal State or the feeding of its population."
>
> "8. A special situation or condition may be deemed to exist when both (a) the fisheries and the economic development of the coastal State or the feeding of its population are so manifestly interrelated that, in consequence, that State is greatly dependent on the living resources of the high seas in the area in respect of which preferential fishing is being claimed; and (b) it becomes necessary to limit the total catch of a stock or stocks of fish in such area in accordance with the provisions of the Convention referred to in paragraph 2 above."

In the post war period in particular, and increasingly in the most recent years, the big development in fish production in the world has been in big, efficient, long range vessels—the stern trawler, the Japanese long-liner, the American tuna clipper, the mother ship, etc. It has been said with some authority that 90 per cent of the fishery resources of the world are underfished and many very large resources are not fished at all. It is also widely stated that mankind badly needs, and will in the future increasingly need, these ocean produced proteins for its diet and its sustenance.

Well, the only way mankind is going to get (or ever has got) proteins to eat out of the high sea is to pay the fisherman more for going to sea and catching them than he can make by working ashore where he can live in comfort with his family.

The way to increase the yield of protein from the sea is to increase the margin of the fishermen's earnings. By and large this cannot be done by raising the price of the catch because of the competition of land-produced proteins which put a lid on fish prices. The other way to do this is by lowering the fisherman's

cost per ton of production. This the fishermen have been doing increasingly in recent years by building larger, more efficient, longer range vessels so that instead of waiting for the fish to come to them they can go to where the fish are.

This results in so much saving in cost per ton of production that a Japanese long-liner working out of Misaki, Japan (for instance) can catch tuna off the Congo, take it Japan to can and get the canned tuna shipped back to the Congo at a cheaper price than the Congo canoe fisherman can catch the tuna off his coast, get it canned and put it on the Leopoldsville store shelf.

The Brazil-Cuba-Uruguay amendment to the Canada-United States proposal would have set back this rapid improvement in efficiency of the high seas fisheries of the world by a generation through putting in the hands of the canoe fisherman and his government the political ability to decrease the efficiency of the long-range, big-boat fishermen so that the inefficient canoe fisherman could compete with him economically. This would have had the general effect of either raising the cost of fish in the world or keeping the production of food from the sea at its present low level.

The effect of this whole amended proposal, had it passed, upon the high seas fisheries of the United States would have been simply devastating. But it was damn the torpedos and fire when ready Gridley. The six mile limit had to be saved no matter what the cost in fish so the full weight of United States diplomacy was put behind this proposal not only in Geneva but in every nook and cranny of the world. The Russian delegate found out from his diplomatic missions all over the world what was going on, thought he was licked, and complained bitterly at what he called the unfair and immoral tactics being used —as did the delegate of Saudi Arabia. And United States diplomacy clicked as it seldom has before. Every manjack around the world put his shoulder to the wheel magnificently and the results were surprising to behold. The Europeans gave in despite the presumptive fishery loss. All allies everywhere joined in. Even the Arab bloc cracked wide open. Just before the voting started the proposal looked so much like a shoo-in that the Russian and Arab both made speeches that practically conceded defeat and rationalized it.

But in the very last minute something came loose. Two Latin American votes that had been promised were not delivered. In consequence the vote on the proposal failed of adoption by the narrowest margin possible. The vote was 54 in favor, 28 against and 5 abstaining. Had one of the 28 *against* votes merely abstained the proposal would have won.

Peculiarly, the two votes that defected at the last moment were countries who would have had the most to gain by the adoption of the Brazil-Cuba-Uruguay amendment into international practice.

This tri-partite proposal had won a nice two-thirds vote in the voting just ahead of this. It got 58 in favor, 19 against, and 10 abstaining. The only countries voting against it were the Russian bloc, the Arab bloc (less a few) and Japan. But with the narrow failure of the Canada-United States proposal to which it was an amendment, this victory of the so called "coastal" States on this fishery issue failed too. The amendment failed when the proposal it was to amend failed.

The defeat of this proposal did not clear the slate, however. International law is made up not only of treaties and the actual practice of nations but also is much influenced by their intent. If this big two-thirds vote which the Brazil-

Cuba-Uruguay proposal got stayed on the record the broad territorial sea States could claim that the *principle* of a preferential right of the Coastal State to the fisheries in the adjacent high seas had been abundantly established by this vote on the Brazil-Cuba-Uruguay amendment. As a matter of fact the delegate of one of these countries rose at once, declared this, and withdrew his proposal to this same effect because he said it was no longer needed.

He knew, as did everyone present, that the vote for the Brazil-Cuba-Uruguay proposal had been mainly the result of United States diplomacy trying to win agreement on the 6 mile territorial sea, and if the proposal of these three countries had been put to a vote on its own merits it could not have won a simple majority, much less a crashing two-thirds majority. Accordingly he was very wise, and quick-witted, to withdraw his proposal and thus prevent a vote on this principle without the support of the six-mile limit attached to it.

However, fortunately for the distant-water fishing community of the world, there was still a Cuban proposal before the house to be voted on which contained this principle in a mild form and did not contain anything about a narrow territorial sea. This was not withdrawn and it came to vote. It lost 22 in favor, 33 against, and 24 abstentions, thus removing that "principle," one hopes, from the world scene.

Eight months has passed since the crashing crescendo of that last day of the Second Conference on the Law of the Sea at Geneva and one can look around and begin to see what effects it had, or will have, on the high seas fisheries of the world. My personal estimation of these effects is that they are, and will be, nil.

This was a peculiar conference. Everybody who was trying to put something across lost. Even though the Russians had dressed up their 12 mile limit in the most palatable form possible and had added much to it to attract votes here and there, it got less votes than it did in 1958 and short of a simple majority. The radical wing of the Arab bloc, which simply wished to harm Israel, played their hand too strongly and their Arab bloc at the last broke up rather badly. Those countries who wanted in the worst way to extend their jurisdiction far out to sea over foreign fishermen overplayed their hand in the last minute of play and lost everything. The United States military and diplomatic people who were prepared to trade all fish away for a narrow territorial sea had barely lost and perhaps they won more by losing so narrowly than they would have won by winning by a narrow margin. Iceland, who has led the fight in favor of extending fishery jurisdiction on the basis of its special case, lost its special case in the welter of other special cases that sprang up like weeds at this conference. Our good friend Canada who had worked so hard in 1958 and 1960 to take only a little fish away from American fishermen had lost even that modest effort.

In the first flush of defeat there was some thought that: (a) the fifty-four nations who had voted in favor of the Canada-United States proposal in plenary might be asked to sign a treaty to that effect among themselves alone, or (b) there might be called a Third Conference on the Law of the Sea.

Soberer thought scotched the first idea soon. With every hour that passed after the narrow defeat of the Canada-United States proposal, enthusiasm for this 54 nation treaty waned. If it were put up for signature and ratification among nations it is doubtful if twenty-five ratifications would come in. Its chief supporters were really straight three mile limit countries both for territorial sea and fisheries jurisdiction and had never liked this compromise. They had only

accepted it as the means toward broad international agreement. If that broad agreement could not be had they wanted no part of the compromise. The Russians with a little effort could get almost that many countries to sign and ratify a twelve mile treaty. So that is a standoff and so it is likely to remain.

The passage of time and the moving of world political thought has made increasingly less likely the calling of a Third World Conference on the Law of the Sea in our generation. The United Nations now has 99 members and before a new conference could be called there will be over 100. These new nations were former colonies. The first thought of a new nation after independence has normally been that the Law of the Sea and narrow territorial seas was the creation of colonial powers and for that reason alone should be voted against. On the record of those colonies that became independent countries directly after World War II, it takes some years of seasoning in international affairs before they begin to see that the freedom of the seas is the protection of the small new country from either economic or military duress. Accordingly it is less likely now than in 1958 or in 1960 that a two-thirds majority could be had in a Conference of Plenipotentiaries on a narrow territorial sea or reasonable fishery limits.

So where does this leave us? In chaos? In a rash of sovereign states claiming a 12 mile territorial sea? In wholesale seizure of foreign fishing boats by "coastal" States? I think not. At least none of these things have happened in the past eight months and none of them appear likely to happen at this moment of writing. I think, to the contrary, that we are thrown back upon the four solid, constructive treaties which resulted from the 1958 Conference on the Law of the Sea, and I think this is good.

The military element in this problem has been solved because it cannot be solved by voting. It is my personal opinion that this is an integral part of the power struggle going on between the Russian Empire and the Free World and that this part of that power struggle is such an important facet of the whole that it cannot be solved prior to a general solution of that problem. Accordingly the military men of neither side will seek another conference on those grounds because it is now abundantly clear that neither side can get a clear two-thirds majority for its position. With them out of the way and not muddying up the waters I believe the fishery people of the world can continue the excellent progress they were making toward solving the fishery problems of the high seas before the military men, international lawyers and top drawer diplomats cut themselves in to the game.

With the military aspect of the problem cancelling itself out of the action this takes us back pretty clearly to the fishery part of the problem. This is composed of two important segments: (a) measures which are needed to ensure that no living resource of the sea is overfished, and (b) measures which are wanted by this State or that State, at this time or that time, to give its less efficient fishermen a preferential position on the fishing ground or in the market so that they can compete on a basis of equality with more efficient fishermen of other countries or even drive them out of the fishery or market.

The Rome Conference, the 1955 and 1956 sessions of the International Law Commission, the Specialized Conference on the Conservation of the Living Resources of the Sea at Ciudad Trujillo, the debates in the General Assembly in 1954, 1956, 1957, and 1958, the First Conference on the Law of the Sea, and the Second, all abundantly show that the nations of the world are not

prepared or able to adopt a general rule which would govern this second point of economic preference which each State should have in respect of the fish of the sea.

As an example, in 1958 and before that, there was very strong sentiment in favor of granting Iceland special rights because of her special needs which had been forcefully and ably presented over the years. The only reason Iceland was not given special rights in 1958 over all other nations was that no formula could be found with which to do this that the Icelanders could accept and that the other nations felt would not damage their fishery situation with their neighbors in another section of the world. The will to do this for Iceland alone, however, was at that Conference.

In 1960 Iceland's economic dependence upon her fisheries had not decreased from what it was in 1958, in 1956, or even in 1946. But Iceland's special case came to vote and lost because in the meantime every other nation who wanted special economic rights at sea had also developed and pleaded its case. There was no general formula which could be devised to fit all of these special cases, several of which (including that of Japan on the opposite side of the fence) were generally thought to have considerable merit.

Perhaps the reason for this inability to develop a formula to handle this economic problem is really two reasons: (a) the economies of the nations of the world at the present stage of history cover too wide a spectrum to be comprehended under a general formula, and (b) the economic status of individual nations changes so rapidly in respect of its neighbors that a static general rule would give a needed advantage at one time which would be grossly unfair at a later time.

Whatever the reason the nations were not able to agree upon any general rule, or even special rule, to give any State a special economic privilege over the fisheries of the high seas in the long series of conferences and meetings on this subject over the past five years.

On the subject of conservation the situation is diametrically different. The nations were able to agree almost unanimously on what conservation was, how it was to be obtained and ensured, and that it was in the entire public interest to see to it that conditions were available which would permit the maximum sustainable production from each of the living resources of the sea—that underfishing and overfishing were equally against the public interest. These matters are well set out in the "Convention on Fishing and the Conservation of the Living Resources of the High Seas" adopted by the 1958 Conference and now undergoing the process of ratification prior to coming into force. I predict that under this document most of the fishery problems now existing between nations can be, and will be, solved.

All of this by no means prevents two, three or more nations who are involved in a fishery making an agreement among themselves as to how the yield of the fishery is to be divided among themselves. There are numerous examples already in existence as to how this can be done. Russia, Japan, Canada and the United States manage the fur seal herds of the North Pacific and divide up their yield among themselves under treaty. Canada and the United States do this in respect of the red salmon and pink salmon of the Frazer River, and manage many other joint fisheries without the necessity of dividing the yield among their fishermen to keep the peace. Russia, Japan, The Netherlands, England and Norway are currently working out a scheme to divide among their

fishermen the sustainable catch of whales in the Antarctic. Despite her avid claim to a 12 mile territorial sea Russia has signed a treaty with England permitting British vessels to fish up to within 3 miles of large stretches of her northern coast. Despite her adherence to a three mile limit England has signed a treaty with Denmark under which British vessels will not fish within 6 miles of the Faroe Islands, and is currently working on a treaty with Norway which will govern the British fisheries off the northern Norway coast in a manner that will be advantageous to the Norwegian fishermen.

The list could go on and include the special agreement between Japan and Australia respecting the fishery for pearl shell in the high seas off northern Australia, the special treaty between Japan, Canada and the United States under which Japan has agreed not to fish for certain types of fish over large areas of the North Pacific. Such special arrangements go back in history, too, as is noted by the special treaty rights United States fishermen have on the Newfoundland coast. They have solved many fishery economic and political problems among nations.

All of these economic treaties and arrangements on fisheries have these things in common: They are an agreement only among those nations directly involved. They do not affect others. Each seeks to solve a specific fishery problem between those nations, and not all fishery problems in the world that are alike or similar, or even all the fishery problems between those particular nations. Each has a definite time limit after which either party may freely cancel and strike for a new bargain. None involve the negation of rights either of that nation or generally.

On top of this there are perhaps a dozen international conservation commissions around the world that are working well and some of them have a history of thirty years and more of good work behind them. All of these commissions have one thing in common. They all hire top scientists who investigate the real world of the ocean and the fish. As their understanding of the ocean and the fish improves the violent arguments among the fishermen, the fish trade and the nations over that particular fishery subside and often evaporate entirely. It is a very difficult task to mount a first class emotional argument against cold, hard scientific facts. Accordingly as the scientific facts accumulate the arguments tend to subside.

Over and above this there is a vast movement in the world for enhancing and building up the scientific investigation of the ocean as a whole on a world wide basis. It seems certain, for instance, that the United States alone will spend one billion dollars more investigating the ocean in this decade than it did in the last. This effort is being joined actively by European countries, Russia and Japan. Competent ocean research establishments are being founded for the first time in Latin American countries and even in newly awakened Africa.

As I have sat through all of these international conferences over the past twelve years I could not help but observe that most of the controversy was based on opposite conclusions drawn by the two sides to a problem, both of which had quite insufficient evidence to base conclusions upon. Also during this period of years I have seen one violent argument after another arise, disturb the diplomatic scene for a time, and then quietly disappear as the scientific facts were accumulated with which to dispel the ignorance upon which the acrid debate had been based.

Accordingly I can not help but be optimistic that the great effort in ocean

research which is now going forward in the world is going to result, as time goes forward, in a lessening of fishery tensions in the world at least as fast as increased fishing effort on the high seas of the world brings new problems.

But perhaps the primary cause for my optimism for the future is the fish people themselves. During the past fifteen years I have had the privilege of sitting down and working with fishermen, fishery experts, and ocean scientists quite literally all over the world, of every color of skin and background, from every continent, both in their home offices and places of business and in international conferences one after the other. These are tough, hard men to deal with, but despite the variety of racial background it has seemed to me that they are more like each other in their thinking than each group is like his own countrymen who are land bound and sea-ignorant. That harsh mistress, the sea, appears to pick about the same type of men out of whatever race goes upon it and these men have common bonds, view points and aspirations which enable them to work together with more facility than landsmen appear to be able to do.

When the eleven nations gathered in Washington to discuss the Northwest Atlantic fisheries in 1949 nobody really thought that an agreement could be had among these diverse interests for the governing of these great fisheries. But in the end they hammered out a treaty that was in several aspects precedent setting and for eleven years it has worked well, with the Russians now even joining in it. But there were no political, military or legal people in that conference. The delegates were the harsh, hard, tough ocean fish people and after a week or ten days of sparring to find weaknesses, and finding none, they sat down and knocked together a treaty.

The Rome Conference was much more difficult than this because not only were there 45 nations actively represented and voting, but about half were represented by diplomats and lawyers who knew little or nothing about the sea or fish or fishermen. But the leaven of tough, bull-headed men from the sea was enough in the end to not only overwhelm the lawyers and diplomats but to settle and agree on the complex technical problems the Conference had been called to solve. Black, brown, yellow, tan and white they worked solidly together behind the scenes in Committees and hammered out an agreement so technically sound that the lawyers and diplomats were frustrated in trying to discover objectionable features in it, and still are.

In my humble opinion this Rome Conference was the most important of the lot in the past fifteen years, because here were agreed upon the principles which have stood up under the examination of the International Law Commission, the diverse nations both individually and collectively in the General Assemblies and the Specialized Conferences, and which will govern the high seas fisheries of the world in our generation and I hope in the next.

The First Conference on the Law of the Sea appeared to be hopeless at the start. Now the issues had gotten so important that the top diplomats and international lawyers headed the delegations, and to many delegations had been added the military men. But it all turned out as well in the end. The important men of the delegations concentrated on the important First Committee and left the unimportant fishery experts pretty much to themselves in the Third Committee.

These were much the same fishery experts who had been at Rome, at Washington, before, and were acquainted with each other through the dozens of meetings and conferences that the fishing fraternity had had over the years

around the world. Accordingly, despite the seemingly impossible task they had, and despite the inabilities of their superiors to agree in Committee One, the largely unmolested fishery people in Committee Three sat down and hammered out a straight, sound, business deal which became the "Convention on Fishing and the Conservation of the Living Resources of the High Seas."

Had the entirety of the membership of Committee One at that conference packed their bags, gone home at the Easter Recess, and stayed there, the fish people of Committee Three would have also settled the breadth of the territorial sea and the issue of fishery limits too. They had an agreement worked out behind the scenes among themselves on these points which would have done that. But the Home Governments, having all their experts in Geneva, made inexpert decisions and prevented this agreement from coming to light. Thus the three mile limit has seemed to disappear from the scene and nothing has replaced it.

So we came to the Second Conference on the Law of the Sea. Here the diplomats, the international lawyers and the military men absolutely dominated. The fish people's advice in all delegations was pretty well ignored and brusquely brushed aside. The upshot was that nothing was agreed upon. None of the remaining problems were solved.

Personally I think this was a good thing. There will be no Third Conference on the Law of the Sea for a long while. The diplomats, the lawyers and the military men have gone back to their lasts and are out of our hair. We fish people have been left the fruits of our labors over these years in the "Convention on Fishing and the Conservation of the Living Resources of the High Seas." This is a sound document under which we can govern ourselves if the others will let us alone to do so. In these short eight months several steps in this direction have already been successfully initiated.

Thus the center of the diplomatic-military storm seems to have passed us by at last, the waves are already subsiding in height and violence, and we fish people can get down to the job of getting food out of the sea with which to feed the hungry world, which was what we hired out to do in the first place.

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Fractionation And Purification Of Triglycerides, Fatty Acids And Methyl Esters From Fish Oils

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INTRODUCTION

THE PRODUCTION OF NEW INDUSTRIAL PRODUCTS from fish oils may very well require the use of purified fractions of fish-oil triglycerides or fatty acids.

Similarly, in order that researchers may follow the various pathways of chemical reactions during the syntheses of fish-oil derivatives, it is quite desirable that the starting materials in the reactions be as pure as possible. Fractionation of fish-oil fatty acids or their monoesters provides a means for purification, at the same time enabling reproducible chemical and physical characteristics of the products. The latter feature overcomes an objection to fish oils; i.e., composition is known to vary with season and geographical location of catch, as well as sex and maturity of the fish.

The following are a few of the problems associated with impure raw materials, to show the importance of purification of fish oils and their derivatives. Chemical reactivities may be impaired owing to the inhibiting effects caused by the presence of impurities. The color of a product may be commercially undesirable because of the presence of needless color impurities in the raw materials of manufacturing. For example, certain chemical products destined for the treatment of textiles may be colorless and should not impart color during aging. The physical properties of both the raw materials and the resulting products may be changed owing to the presence of undesirable impurities. These impurities may be either trace amounts of materials of different chemical classifications, or fairly large amounts of some unwanted material in the same chemical class, such as saturated fatty acids in the presence of unsaturated homologs.

METHODS

The most common methods for the fractionation and purification of fish oils and their derivatives include (1) liquid-liquid extraction, (2) fractional crystallization at reduced temperatures, (3) fractionation of urea-inclusion compounds, and (4) fractional or multistage molecular distillations. These methods may be considered as being the most practical for commercial operations. Space does not permit the discussion of other separation techniques that have use in various laboratory operations.

Liquid-Liquid Extraction

In the liquid-liquid extraction method, it is necessary to find a solvent system in which the mixture of fish-oil triglycerides or fatty acids, etc., is partially miscible and in which one component or chemical class of the mixture is more soluble than the others (Pratt, 1953). One such choice of solvent system suitable for fatty acids is isooctane, a relatively non-polar hydrocarbon, and furfural, an active polar solvent immiscible in the hydrocarbon (Freeman, 1942). In this case, an all-liquid system is established, whereby the fatty acids are partitioned between the two phases of the solvent.

Separations of fatty acids, as well as natural triglycerides, involving selective action of solvents give rather poor separation efficiency owing to mutual solubility characteristics. In spite of this poor efficiency, industrial designs of liquid-liquid extraction equipment have improved in recent years to produce very effective separations of fatty acid mixtures (Treybal, 1958). One such design includes a centrifugal contactor in conjunction with a countercurrent flow of the two solvents. Data from this latter process applied to fish oils was not found in the scientific literature.

Fractional Crystallization at Reduced Temperatures

The fractional crystallization method, in which one component of a mixture

to be separated is crystallized, overcomes to a large extent the mutual solubility effects mentioned above. Saturated fatty acids or methyl esters may be separated by virtue of differences in carbon chain length, or those of the same chain length may be separated by differences in degree of unsaturation (Kistler, *et al.* 1946; Muckerheide, 1954).

Table 1 illustrates the effectiveness of fractionating tuna-oil methyl esters by low temperature crystallization from a methanolic solution. The original mixture of methyl esters dissolved in methanol was cooled stepwise from room temperature to -60°C. The result was a concentration of the more highly unsaturated fatty acids, as reflected by the changing iodine values, as lower temperatures were used (Kolb and Brown, 1955).

TABLE 1

TUNA-OIL METHYL ESTERS FRACTIONATED BY LOW TEMPERATURE CRYSTALLIZATION FROM METHANOL

Crystallization fraction	Yield	Iodine value, Hanus[1]
	Wt. —%	
Original	100	168.0
Precipitate, —5°C.	22.0	40.1
Precipitate, —25°C.	14.9	123.9
Precipitate, —60°C.	44.1	199.2
Filtrate, —60°C.	19.0	278.4

[1] Analysis made on the fatty acids.

This method of fractionation removes a large part of the color impurities by concentrating them in the final filtrate fraction. Also, the saturated carbon chain acids are generally separated in the initial fraction, producing a nearly pure unsaturated product after one crystallization. A disadvantage of this method is the lack of separation of color bodies and polymeric material from the polyunsaturated fraction. The latter fraction is the most valuable asset to the development of new products from fish oils. In regard to the fish-oil triglycerides, this method would have only a slight effect in the separation based on unsaturation by assuming a more or less random-type distribution of fatty acids on the glyceride molecules.

Fractionation of Urea-Inclusion Compounds

The use of urea-inclusion compounds for the fractionation and purification of fatty acids and their monoesters has become part of a widely accepted laboratory method. Triglycerides, by the nature of their structure, have very little utility in this area of purification. Virtually all natural occurring fatty acids will form inclusion compounds or adducts with urea (Schlenk, 1954). Extractive crystallization with urea provides a simple and efficient means for the separation of fatty acids on the basis of their degree of unsaturation. The method may be adapted to commercial scale operation (Rosenstein and Gorin, 1957); however, it has the usual disadvantages of most crystallization processes.

Work at the Seattle Technological Laboratory has shown the effectiveness of urea-inclusion compound fractionation applied to fatty acids from menhaden oil (Domart, Miyauchi and Sumerwell, 1953). Table 2 shows resultant data

TABLE 2

MENHADEN-OIL FATTY ACIDS FRACTIONATED BY UREA CRYSTALLIZATION AT DIFFERENT TEMPERATURES[1]

Fatty acid fraction	Yield	Iodine value, Hanus
	Wt. —%	
Total	100	160
25°C. Complexes	27.8	19.4
1°C. Complexes	17.4	46.0
—18°C. Complexes	6.0	82.7
—30°C. Complexes	0.2	—
—30°C. Filtrate (non-complexed)	48.4	255

[1]Starting mixture contained 9.1:1 mole ratio of urea to fatty acids at 25°C. in methanol.

for urea crystallization of fatty acids at various reduced temperatures. The molar ratio of urea to fatty acids was 9.1 to 1.0, respectively, at the start of the process. As the temperature was lowered, successive fractions of urea adducts or complexes formed according to the degree of unsaturation of the fatty acids. The iodine value data reflect this change in unsaturation.

In Table 3, data are shown for the effect on fractionation by changing molar ratios of urea to fatty acids, while at the same time maintaining a constant temperature of crystallization. As higher ratios of urea to fatty acids are used, the yield of urea adducts increases. This has the effect of increasing the degree of unsaturation in the non-adduct forming fraction. Therefore, one has flexibility in the technique that is used, depending on the extent to which one wishes to fractionate by this method. An interesting innovation of urea-inclusion compound fractionation is to combine the process with a countercurrent liquid extraction system (Sumerwell, 1957).

Here, as in the case of the previously described methods, color bodies are concentrated in the final filtrate fraction, i.e., the fraction containing the valuable polyenoic acids. When compared to the solvent crystallization method (cf., Table 1), urea complexing produces higher yields of the most unsaturated fraction of fish-oil acids. In the laboratory, this method is most helpful in obtaining concentrates of eicosapentaenoic and docosahexaenoic acids (Abu Nasr, Potts and Holman, 1954), from which the acids may be obtained in purest form by distillation combined with partition chromatography.

Distillation Methods

The ability to separate components of a mixture by distillation methods is limited by the differences in boiling points of the components. Theoretically, it should be possible to completely separate by fractional distillation fish-oil fatty acids that differ in chain length by two carbon atoms (Potts, 1956). It is not possible to separate by distillation the saturated and unsaturated fatty acids of equal carbon chain lengths. Ordinary distillation of fatty acids from fish oil is complicated by the fact that high temperatures are required, and at these high temperatures fatty acids are thermally unstable. In the case of fish-oil triglycerides, ordinary distillation techniques are absolutely impractical.

TABLE 3

THE FRACTIONATION OF MENHADEN OIL FATTY ACIDS[1] WITH DIFFERENT MOLE RATIOS OF UREA IN METHANOL AT 1°C.[2]

Mole ratio of urea to fatty acids	Yield of fatty acids from complexes	Hanus I. V. of fatty acids from complexes	Yield of fatty acids from filtrate	Hanus I. V. of fatty acids from filtrate	Unrecovered fatty acids
	Wt. —%		Wt. —%		Wt. —%
4.6:1	11.6	12.8	80.8	192.7	7.6
9.1:1	29.8	22.1	61.6	243.4	8.6
13.8:1	49.4	48.1	41.6	308.9	9.0
18.4:1	61.0	54.5	36.4	330.7	2.6
23.0:1	63.0	72.7	34.2	341.6	2.8

[1]The Hanus iodine value for the menhaden oil fatty acids from which these fatty acids were prepared was 159.5.

[2]All values represent averages obtained by treating triplicate 50.0 gram samples of the fatty acids.

The techniques of fractional and molecular distillations at reduced pressures permit lower temperatures to be used to bring about distillation. Fatty acids and methyl esters of carbon chain lengths up to C_{20} can be separated satisfactorily by fractional distillation, between 1 and 50 millimeters mercury pressure, without much thermal deterioration. Above C_{20} chain lengths, the thermal hazard becomes greater. Distillation has the advantage over the other separation methods in that polymeric materials, such as major color bodies, can be separated from fish oils or fish-oil fatty acids.

Triglycerides can be effectively purified by molecular distillation methods. Here, the operating pressures are of the order of 10 microns Hg. Fractionation by molecular distillation methods can be accomplished by the use of multiple stage units, or by some means that permits recycling of undistilled portions through a single distillation unit. Depending on the design of the distillation equipment, it is possible to minimize the thermal hazard by minimizing the contact time of the fish oil product with the heated or distillation surface of the still.

TABLE 4

CRUDE MENHADEN OIL FRACTIONATED BY MULTISTAGE MOLECULAR DISTILLATION

Fraction	Yield	Temp.	Pressure	Iodine value, Hanus	Ethylenic bonds per mole
	Wt. —%	°C.	Micron		
Original[1]	100	—	—	161	1.24
1	4.5	185	17	124	0.85
2	24.5	208	15	122	0.97
3	45.5	200	15	164	1.26
4	22.5	195	15	191	1.44
Residue	3.5	—	—	232	1.66

[1]Crude menhaden oil produced from fish caught in the Gulf of Mexico.

The data in Table 4 are typical of the results obtainable by multistage molecular distillation of crude menhaden oil (triglycerides). In this case, an oil of iodine value 161 can be easily separated into major fractions having an iodine value range of 122 to 191. It is expected that the last major boiling fraction is a concentrate of the highly unsaturated portion of the oil, but that it may very well contain saturated groups. Owing to the structural make up of triglycerides, the data would not be expected to show appreciable separation on the basis of chain length and unsaturation.

Multistage molecular distillation of fish-oil fatty acids will permit fractionation, to a degree, on the basis of chain length. In fish oils, the longer chain fatty acids accompany the higher degrees of unsaturation. Stoffel and Ahrens (1960) report that the C_{20}- and C_{22}- pentaegnoic and C_{22}- hexaenoic acids comprise 23.4 per cent of the total fatty acids derived from menhaden body oil.

The results in Table 5 show the separation of fatty acids into four major fractions, each amounting to from 20 to 30 per cent of the total mixture. Both the iodine values and the calculated average number of ethylenic bonds per acid fraction indicate the success of molecular distillation to purify and fractionate on the basis of unsaturation. As stated earlier, these results are a consequence of the degree of unsaturation that accompanies the higher boiling or longer chain fatty acids.

It may be interpreted from Table 5 that the fourth fraction of distilled fatty acids should contain major amounts of pentaenoic and hexaenoic acids. However, the average of 4.45 ethylenic bonds per fatty acid in this fraction indicates that the fraction probably contains appreciable amounts of dienoic, trienoic, and tetraenoic acids. It can be determined from the data that by combining fractions 3 and 4 it is possible to obtain a fraction of over 50 per cent of the oil that has an iodine value of approximately 270.

TABLE 5

MENHADEN-OIL FATTY ACIDS FRACTIONATED BY MULTISTAGE MOLECULAR DISTILLATION

Fraction	Yield	Iodine value, Hanus	Ethylenic bonds per mole
	Wt.-%		
Original	100	191.0	—
1	24.9	83.2	0.85
2	19.8	127.0	1.35
3	30.1	215.8	2.48
4	21.6	346.6	4.45
Residue	3.6	—	—

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The Multiple-Use Of Shrimp Trawlers

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The history of world fishing is filled with examples of fisheries which have failed to survive and in most cases the failures have resulted from the inability of the fishermen to make a profit using hand-labor; the Grand Banks baited trawl fishery for cod is an example. How many of the graceful schooners sail each year from U. S. ports?

Any fishery which in these rapidly changing times does not bend constant effort to reducing both man-power and cost will eventually find itself no longer operating. Such is the precise condition of the menhaden industry today. We have some million-dollar menhaden boats but they cannot compete with cheap imported fish meal and the menhaden industry is calling for help. In the past three years we have also heard calls from the shrimp industry for quotas, tariffs and other forms of government aid.

I, in turn, will call for government aid but of a type which will enable the shrimp and menhaden industries to compete with foreign imports without tariffs and quotas. I appeal for money for the U. S. Fish and Wildlife Service to develop and prove once and for all that menhaden and other pelagic fish can be profitably caught with a standard southern shrimp trawler; that at the end of the menhaden fishing season the trawler can quickly convert to shrimping and work the rest of the year, thus taking full advantage of the productive working time of the vessel. In short, to develop true multiple-use of southern shrimp trawlers.

If this is such a simple matter, it might well be asked, why hasn't it been done before? The answer is that it has been done before, many times, but not properly. To a degree, it is being done today by a few boats but is based on obsolete gear. Let us examine some of the pioneer activity in this field.

One of the best-documented efforts to purse-seine with a trawler was the shrimper "Jeff Davis," captained by Carl Carlson for the U. S. Fish and Wildlife Service during the early 1940's. This vessel based at Fernandina Beach and after many months of trial and error succeeded in catching menhaden with a purse seine set off the deck of the vessel, west coast style. This project came to naught, after months of hard work, because war-time fish bailers, who unloaded the boats at the fish factory, threatened to strike if they had to work in the "Jeff Davis" hold—insufficient head-room made it inconvenient.

In 1951 Captain Joe Jett of Reedsville, Virginia, rigged the 110-foot subchaser "Sea Hawk" as a west coast seiner but there were gear and crew problems here, also, and the project was given up.

In 1956, after the advent of the powerblock the writer rigged the "Florida Boys," a standard Florida shrimp trawler, with a seine and with a powerblock suspended from the boom. This was what might be characterized as a "poor-boy" project: the owners lent the boat, the powerblock manufacturer lent the net-puller, Wallace Menhaden Products and people like Harry Sahlman, Young Hall and Bill Hardee contributed money. Nassau Fertilizer and Oil Company lent a seine; many others contributed small items of gear. We went fishing with the "Florida Boys," with the greenest crew of purse-seine fishermen ever collected on one deck—and we caught fish. Not many, it's true, but at least we didn't lose the seine. In three days we caught 25 tons of menhaden, solved innumerable problems and learned much—and then our cotton seine fell apart from old age and hard service. So ended the project.

In 1958 Harvey Smith, of the menhaden Smiths, brought the 60-foot "Queen of the Sea" around from the west coast, rigged as a standard west coast purse seiner. This vessel has fished in the Chesapeake Bay area for a year or two but has operated only sporadically and cannot yet be labelled a success.

Let us examine what it is we are trying to do with a small purse seiner; our intention is to surround a school of fish with a fine-mesh seine roughly 1200 feet long by 60- to 70-feet deep. Once surrounded, we must close the bottom

by means of a purse-line, pull the net back on board, pocket the fish in one end and bail them out of the net into the boat. We are, in short trying to replace 20 men in two clumsy purse boats with 5 men on a stable trawler. On the face of it, this seems no difficult task but one factor makes it difficult: the inertia of shrimp and menhaden fishermen who prefer to lie idle at the dock rather than learn new skills.

If we examine the failures of the past we find that only one vessel, the Smith "Queen of the Sea," could be called adequately financed—the others were all "poor-boy" affairs. Another reason most of these trials failed is that commercial fishermen were used as crews. It is axiomatic that experimental fishing must be done by professional experimental fishermen. In many instances, the vessels made mistakes made by their predecessors, repeating mistakes which had been earlier solved. The professionals examine the published literature before they proceed to experiment.

If there have been failures, with such a relatively simple operation, have there been any successes? The answers here is a resounding "Yes." In British Columbia the Canadians captured up to 1,000 tons of fish per set with an almost identical boat. In Peru, similar vessels have flooded the world market with fish meal. Closer to home, Charles Bennett of Apalachicola, Florida, has succeeded in catching thread-herring in commercial quantities with a 62-foot Diesel Engine Sales, Inc. trawler and a powerblock; in New England a standard 67-foot shrimp trawler averages 4,000-5,000 tons of menhaden each year, fishing only 20 weeks.

This last vessel, the "Miss Point Judith," is fished with a seven-man crew, no powerblock, and is captained by Harold Loftes of Wakefield, Rhode Island. Using a modified Gloucester mackerel-seining rig, which employs a towed 40-foot seine boat, the "Miss Point Judith" operates profitably on menhaden and quickly converts to dragging for bottom fish. The Gloucester rig is, however, regarded as obsolete since fewer men can handle the seine by eliminating the large seine skiff and adding a powerblock.

One outstanding success, the only vessel of its kind in the Gulf of Mexico, is the 50-foot steel combination "Cabo Villano II" of Tampico, Mexico. Built like a standard steel shrimp trawler this vessel handles a purse-seine easily and catches mullet, jack crevalle, snook and razorbelly in profitable quantities.

Examining the successes and failures of the past we can formulate several rules for successful multiple-use trials:

1. The work should be done by professional experimental fishermen, i.e., the Bureau of Commercial Fisheries.
2. The trials should be adequately financed and not dependent on revenue from fish caught for continuation.
3. All trials should take advantage of the successes and failures of the past.

It is in order to ask: "What would be the result of developing multiple-use shrimp trawlers—in short, what's the use?" One immediate advantage would be to broaden the bases for both the menhaden and shrimp industries. The menhaden industry could better compete with Peruvian imports; the hard-pressed shrimper, at times facing months of poor production, would be able to profitably operate his vessel.

The answer to this, as in all problems dealing with commercial fishermen,

is that someone must show the way. In the South the only people with the skill and patience required are the men of the U. S. Bureau of Commercial Fisheries. It is up to the fishing industry to make plain to the Fish and Wildlife Service in Washington that they must not overlook the fact (as they sometimes do) that shrimp and menhaden are this country's two greatest fisheries resources, and then it is up to the fishing industry to help Fish and Wildlife get the money needed to implement the experimental fishing.

To the skeptics I merely point out the Pacific Coast tuna industry: three years ago it was almost bankrupt; and spent its time and money with hat in hand begging Congress to protect it from hard-working foreigners just as our shrimp and menhaden industries are doing today. Converting from live-bait boats to purse-seiners, the Pacific Coast tuna fishermen are now prosperous, new boats are again building, and thousands of shrimp trawlers now working will accomplish the same result for the shrimp and menhaden industries.

A Challenge to the Fish Meal and Oil Industry in the Gulf of Mexico

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THE CLUPEOID OR HERRING-LIKE FISHES constitute the most abundant fishery resource used by man and account for nearly one fourth of the world's total fish production. Historically the herrings have been utilized directly as food, but in recent years these fishes have achieved greater importance as the principal raw material of the fish meal and oil industry. The distribution of these fishes is worldwide. Most of the numerous species in the group occur in the ocean where they are principally confined to the coast or at least are not concentrated far from shore.

There are other important characteristics which make the herring-like fishes particularly desirable to the fish meal and oil industry (1) Most of these fishes normally occur in dense schools. Furthermore, they generally school by species, and the individual schools usually consist of fish which are fairly uniform in size. These schooling characteristics facilitate mass production methods of catching, handling, and processing. (2) The herrings are plankton feeders and thus form one of the early links in the food chain; consequently they are among the most numerous fishes. The menhaden, for example, is one of the few fishes that feeds directly on the basic food producer in the ocean and thus represents a two-link food chain—the shortest possible and uncommon among the fishes in the sea. (3) They grow rapidly and reach maturity early; consequently many species can be utilized at the end of their first year of life and probably afford the maximum yield by the end of their second or third. (4) Many of the clupeoids undertake seasonal and annual migrations which lead them into areas where they can be conveniently caught. (5) Fishes in this group are relatively high in protein and body fat.

Because of these and other characteristics, there is little doubt that the

clupeoid fishes in the Gulf of Mexico constitute the most promising resource, yet of the 25 generally recognized species in this group which occur in the Gulf and contiguous waters, only two—the Gulf menhaden, *Brevoortia patronus,* and the anchoveta, *Cetengraulis edentulus*—are being utilized by the fish meal and oil industry.

In the search for basic knowledge of the species which constitute the menhaden resource and their distribution in time and space, several survey trips were made along the southeast coast of the United States during late 1958 and 1959. Results revealed that the stocks along the Atlantic and Gulf coasts were not isolated and separated from each other as believed, but were distributed continuously around the Florida peninsula (Reintjes, 1960). This finding showed that the distribution of these fishes in the Gulf of Mexico was much greater than was reported. During the past year, therefore, efforts were directed toward the collection of the various species of menhaden in coastal waters from Fernandina Beach, Florida, on the Atlantic coast to the Gulf of Campeche. A second objective of the field work was to obtain information on the distribution and relative abundance of other herring-like fishes of potential value to the fish meal and oil industry.

Based upon field observations, discussions with fishermen and processing plant operators, and extensive collections, it was obvious that the clupeoid fishes in the Gulf of Mexico are much more widely distributed and occur in greater abundance than previously known.

The primary purpose of this paper is to summarize present information on the range, relative abundance, and seasonal occurrence of several species in the hope that it may stimulate exploration and subsequent utilization by the fish meal and oil industry.

The Gulf menhaden at present is the more important of the two species being utilized. Juveniles occur in schools in the open waters along the Gulf coast from Mexico to southern Florida. Larvae appear in salt-water lagoons and estuaries along the Gulf coast during the winter months, and young-of-the-year juveniles are encountered in these same areas throughout the summer. This species supports the commercial purse-seine fishery which is conducted generally from mid-April to mid-October in the vicinity of Apalachicola, Fla., and along a relatively short stretch of coast lying between Alabama and Texas. Samples from the catches indicate that the fishery is based on 1- and 2-year-old fish. Older, sexually mature fish are generally absent from the catches. Collections from southern Florida and Mexico (southward to Yucatan) have shown that during the summer adults increased in size toward the southern limits of the range; however, the abundance of both juveniles and adults appeared to diminish. The occurrence of large, adult Gulf menhaden in southern Texas and in the vicinity of Veracruz in mid-summer suggests a greater abundance of this species in the southern Gulf of Mexico during the winter when it disappears from more northerly waters. It also is of interest to note that spawning adults of this species were taken during the past two winters off the east coast of Florida, and some of the catch in the Indian River area this fall has consisted of large, spawning adult fish provisionally identified as Gulf menhaden. These averaged about 10 inches in length. In summary, present information indicates that either this species has an unusually short life-span, which based on present information appears unlikely, or the adult segment of the population is not being utilized by the fish meal industry. If the older,

larger fish exist in concentrations—and we believe that they do—and if these could be located and caught, they could appreciably increase the yield and afford a greater economic return than is now being realized from the species population.

The finescale Gulf menhaden is known to occur from eastern Louisiana to the Gulf of Campeche (Christmas and Gunter, 1960) and there is evidence to suggest that it extends around the Yucatan Peninsula and into the Caribbean Sea. This species does not occur in abundance in purse-seine catches; however, individual landings consisting entirely of finescale Gulf menhaden have been reported in western Louisiana waters and off Campeche. This past summer, large adults were present in beach-seine, gill-net, and shrimp-trawl landings along the entire Texas coast. Since none of these gears is adapted to catching menhaden, even in areas of known abundance, their occurrence in the catches is of significance. Juveniles of this species also were obtained as far westward as the Laguna Madre of Texas. It is concluded that this species constitutes an unknown resource which apparently occurs in greatest abundance from Corpus Christi, Texas, to the lower Gulf of Campeche.

Yellowfin menhaden are distributed continuously from the central east coast of Florida to the delta of the Mississippi River. A gill-net fishery for this species for bait purposes is conducted throughout the year in Indian River, Florida. Landings in recent years have averaged about 325,000 pounds, and the fish have been available throughout the year. Fish in the catches are consistently large, ranging from about 8 to 12 inches in length. Adults of this species also have been caught by gill nets in Florida Bay near Marathon during the winter and off Naples in early spring. Eggs, larvae, and juveniles of this species have been collected in Indian River, and juveniles have been encountered in abundance in estuaries near Everglades City, Naples, Punta Gorda, and in Tampa Bay, Fla. It appears that the areas of greatest abundance of yellowfin menhaden are from Cape Canaveral to St. Lucie Inlet on the Atlantic side and from Cape Sable to Sarasota, Fla., in the Gulf of Mexico. The whereabouts of the younger adults are unknown, yet it probably is this segment of the species population which offers the greatest potential to the fish meal and oil industry.

The thread herring, *Opisthonema oglinum*, occurs generally throughout the Caribbean and along the Gulf coastal states southward to the Gulf of Campeche. This species was found to be available in large quantities throughout the year along the west coast of Florida and appeared to be present in large numbers in the shallow coastal waters of the remaining Gulf states during the summer. Based on surface school observations and the results of experimental fishing by Bureau's exploratory vessel M/V *Oregon*, it has been estimated that this species is more abundant than the Gulf menhaden. It can be caught with standard menhaden purse-seine gear since substantial landings are made each fall at Beaufort and Southport, N.C., when schools are encountered in the shallow waters along the shore. The oil yield at that time of year generally exceeds that of menhaden of comparable size. The fish reach a maximum length of about 12 inches.

Several species of anchovies occur along the Gulf coast and through the West Indies. The most abundant species appeared to be the bay anchovy, *Anchoa mitchilli*, which is distributed in the northern and western Gulf to Texas where surface schools are available from early spring through late

autumn. Indeed Gunter (1945) has estimated this to be the most numerous species in Texas coastal waters. The anchoveta, *Cetengraulis edentulus,* occurs in quantity in southern Gulf of Mexico and is the principal species presently being exploited by the purse-seine fishery in the Gulf of Campeche.

Other clupeoids such as the scaled sardine, *Harengula pensacolae;* Atlantic round herring, *Etrumeus sadina;* and the Spanish sardine, *Sardinella anchovia,* may also exist in mid-water depths in commercial quantities, but there is little precise knowledge of their seasonal distribution and relative abundance.

The Bureau's Pascagoula, Miss., Exploratory Fishing Base has gathered a wealth of information on the geographical distribution, seasonal occurrence and relative abundance of the Gulf clupeoids. These catches are being examined in detail for species identification and length, weight, and maturity condition of the fish. The Bureau's Biological Laboratory at Galveston also is gathering information on those clupeoid species which appear in the industrial trawl fishery conducted in the northern Gulf. Summaries of these data will be of great value to those individuals within the fish meal and oil industry who are interested in locating and exploiting new stocks of fish.

It is recognized that many of the shallow waters close to shore are known and, to a large extent, are being exploited by the present purse-seine fishing fleets, but it also appears that, either because of gear limitations or lack of exploration, there occur in these same areas commercial concentrations of fishes suitable for reduction into meal and oil which are not being utilized. It also is recognized that there are many practical problems which tend to limit or discourage a systematic program of new resource development, but it also must be pointed out that once the biological potential is recognized that, because of its trained personnel, equipment, and facilities, the industry is in the best position for making a complete appraisal of the economic potential of the resource, from the development of efficient methods of capture to the processing of the raw material. Most of the crews, vessels, and plants are idle during the winter months when they could be utilized for these purposes.

If further development of the clupeoid resource in the Gulf of Mexico is contemplated, the following may serve as useful guidelines:

(1) Exploratory fishing should be conducted to ascertain the whereabouts of Gulf menhaden during the winter months and determine whether fish larger and older than those presently being caught exist in concentrations within the region. The most likely places of occurrence appear to be along the southern coast of Florida and along the eastern coast of Mexico.

(2) Initial utilization of the yellowfin menhaden population probably should be attempted during the winter months in the vicinity of the Indian River and along the southwest coast of Florida.

(3) Initial efforts to locate the finescale Gulf menhaden population probably should be attempted along the south Texas coast and the Gulf of Campeche.

(4) Until considerably more information is available, the potential of the yellowfin and finescale Gulf menhaden resources should be considered much smaller than that of the Atlantic and Gulf menhadens.

(5) Winter capture of menhadens, anchovies, scaled sardine, and other

clupeoids probably will require the development of fishing methods and equipment somewhat different from those presently employed by the menhaden purse-seine fishery. Possibly auxiliary boats employing lampara or small-mesh purse seines or mid-water trawls would be most satisfactory in the company of large refrigerated menhaden vessels serving as carriers. The exploratory fishing staff at Pascagoula, Mississippi, is working on the problem of gear design.

(6) The thread herring resource appears to offer the greatest potential as an additional source of raw material during the winter. The most likely area for initial exploration is along the west coast of Florida.

In summary, the work conducted during the past several years has demonstrated that number of the clupeoid fishes are more widely distributed in the Gulf of Mexico than was believed, and it probably is the winter concentrations of the several species mentioned which offer the greatest challenge to the fish meal and oil industry.

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WEDNESDAY—NOVEMBER 16

Chairman—RICHARD T. WHITELEATHER, *Assistant Regional Director, Bureau of Commercial Fisheries, St. Petersburg Beach, Florida*

New Methods of Purse Seining for Tuna in the Eastern Pacific Ocean

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THE UNITED STATES TUNA FISHERY originated in California in 1903 when albacore were canned successfully for the first time. Through the years, as demand for the canned product increased, there was a gradual expansion in the number of tuna vessels fishing for yellowfin and skipjack tunas in the more distant tropical waters. By 1930, prospecting for these species had extended south to the Galapagos Islands and waters off Central America. The fishery was further extended to waters off northern Peru in 1950 and to waters off northern Chile in 1958.

The production of tuna and tuna-like fishes by United States vessels rose to a peak in 1950. Since that time economic difficulties within the industry have resulted in a continuous decline in the number of vessels fishing for tuna and subsequently a decline in the total production.

Many bait fishing vessels were constructed during the post-war expansion period of 1946-1951. Since then, new construction has been limited to two or three vessels per year, a figure considerably less than losses due to sinkings, foreign transfers and withdrawals of older vessels from the fleet.

The tuna purse-seine fleet expanded, after World War II, from a nucleus of the larger sardine vessels. They fished for yellowfin, skipjack and bluefin tuna from February to August each year, laying-up or fishing for sardines during the fall period. These vessels were small (by bait vessel standards) and carried an average of about 120 tons of tuna. Additional vessels were added to this fleet during the post-war boom in vessel construction. Some of these new seiners were quite large (150-350 tons carrying capacity) but with one exception the large seiners were unsuccessful and were converted to bait fishing. The fishing range of the tuna purse-seine fleet was somewhat limited by vessel size and most vessels, other than the largest craft, resorted to transshipment of their catches when operating south of about 15 degrees north latitude.

Table 1 shows size of each fleet (California-based), their catches by species, catch-per-vessel and the approximate price of yellowfin tuna for each year during the period 1947-1959. Albacore landings have not been included, as they represent an extremely small portion of the catch of the large tuna vessels.

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TABLE 1

CATCH-PER-SPECIES, CATCH-PER-VESSEL AND APPROXIMATE PRICE OF YELLOWFIN (CALIFORNIA FLEET) DURING THE YEARS 1947-1959 FOR BOTH TYPES OF GEAR

	Bait Vessels				Purse-seine Vessels				
Year	Number of vessels	Yellowfin	Skipjack	Tons per vessel	Number of vessels	Yellowfin	Skipjack	Bluefin	Tons per vessel	Yellowfin price per ton (approx.)
1947	176	61,566	21,865	474	84	12,686	3,988	7,637	289	310
1948	198	78,385	26,746	531	89	17,352	2,230	2,036	243	340
1949	205	78,817	35,727	559	79	12,148	2,214	1,589	202	310-340
1950	204	72,665	54,602	624	67	17,478	6,329	1,004	370	310
1951	225	72,200	50,285	544	78	7,273	6,383	1,316	192	310
1952	202	72,871	36,072	539	64	15,141	5,298	1,803	348	310-320
1953	190	48,415	56,011	550	64	17,770	5,700	2,571	407	320
1954	182	51,302	67,484	653	69	8,405	9,390	9,041	389	330-350
1955	172	47,498	45,334	540	63	13,540	5,716	5,317	390	260-310
1956	175	54,221	57,033	636	64	20,095	2,787	5,246	440	270
1957	170	52,303	42,258	556	50	16,024	2,961	6,940	519	250-270
1958	159	41,117	56,780	616	44	20,088	2,144	10,352	741	250
1959	141	26,807	43,183	496	53	27,377	6,024	7,217	751	250

Source: Broadhead and Orange, 1959, U.S. Dept. of Interior Circular No. 65, 1959, and U. S. Tariff Commission Report, 1958.

Immediately evident is the steady decline in recent years in the number of operating units in each fleet, coincident with the steadily falling ex-vessel price of tuna. The increase in the numbers of purse-seine vessels in 1959 (and again in 1960 but not shown) is the result of the conversion of the bait vessels to net operations. No new construction has been added to either fleet in the past several years.

Purse-seine fishing was not particularly successful during the early part of the period under discussion. These vessels produced less than 20 per cent of the yellowfin and only about seven per cent of the skipjack tuna catch. Their catches of bluefin tuna were erratic and were dependent on the availability of the fish to the fishery and on demand for this species. By 1956 this fleet of aging vessels appeared to be heading for extinction by attrition. However, beginning in 1957, and before large-scale technical changes were introduced to the fleet, the catch-per-vessel began to increase substantially. Concurrently, several technological advances were being pioneered by certain vessels in the fleet. These caused two significant trends to develop:

1. Modernization of the existing fleet of purse-seine vessels, beginning in 1958 and continuing through 1959.

2. Conversion of many of the bait vessels to purse-seiners, beginning in 1958 and accelerating during the latter part of 1959 and early 1960.

Technological Changes

A preliminary documentation of the technological advances within the tuna fleets and their effects on the costs of catching tuna was made by Orange and Broadhead (1959). These are summarized briefly with certain additional information on fishing experience during the past year.

A. Power Block

This mechanical means of retrieving the tuna seine was introduced in the latter part of 1955; an adaption from the original design used for salmon and herring seine operations in the Pacific northwest. By the end of 1958, six vessels in the fleet were equipped with power blocks, and a year later almost all of the fleet had abandoned the slower method of strapping the net aboard the vessel. Records[3] of individual sets show that use of the power block, in combination with the nylon net, has cut the time of "no catch" sets in half, or from two hours to one hour, on the average. Sets-per-fishing-day have increased from an average of 0.7 during the period 1952-1957 to about 1.0 during 1958 and 1959.

B. Nylon Nets

The all-nylon tuna seine was introduced to the California tuna seine fleet in 1956. Despite immediate recognition by the fishermen of its superiority over cotton, several years passed before the nylon net became standard in the fleet. The delay was primarily due to economic factors; two of which were lack of capital and the fact that many of the costly cotton nets were still in serviceable condition. By the end of 1959, practically all of the fleet were using the nylon net.

Scofield (1951) reported that the average cotton tuna seine measured 325

[3]Inter-American Tropical Tuna Commission.

fathoms in cork line length and 32 fathoms in depth. Bulkiness prevented the use of nets of larger dimensions. Today, using the lighter and stronger nylon webbing, the nets used by the larger seiners average some 425 fathoms on the cork line and 42 fathoms in depth. The body of the net is 4¼- or 4½-inch stretched mesh, 42-thread nylon, with heavier and larger mesh nylon near the lead and cork lines. These nets represent an investment of about $45,000 each.

Catch-per-successful-set for the period 1952-1958, given by Orange and Broadhead (1959), for a select group of 34 of the older type seiners, was shown to fluctuate within a narrow range of 13 to 16 tons per set. During 1959 the catch-per-successful set rose to 18 tons for this same group of vessels. In all years the number of successful sets has been approximately half of all sets made.

C. Handling, storage and refrigeration changes

Until quite recently, many vessels in the purse-seine fleet employed ice as a means of refrigerating their catch. Brine freezing, developed in the late 1930's and used by nearly all of the bait vessels, was not practical for many of the seiners. The latter were too small for effective conversion to brine, and they continued to use ice. In 1957 a new method of refrigeration called brine-spray was developed. Using spray rather than a full tank of brine water to freeze the tuna, the method was so successful that a large number of the seiners converted to its use, with subsequent increases in the efficiency in handling catches of fish. Bait vessels which have converted to net fishing have retained their brine wells with some modification to permit the installation of the net platform on the vessel stern.

Ancillary fishing equipment has also been improved. The power skiffs have been enlarged, and their buoyancy increased. Brailing and stowage of the tuna has been expedited by installation of a central hopper with chutes to the various brine wells. Technical descriptions of the many gear modifications within the fleet are currently being undertaken by the Gear and Exploratory Fishing Section of the Bureau of Commercial Fisheries.

D. Land-based Scout Aircraft

During the period of prosperity and post-war expansion of the tuna fleet, many of the larger bait vessels carried their own float planes for spotting schools of tuna bait and tuna. As the ex-vessel price of tuna declined, vessel operating costs were pared, and these aircraft gradually disappeared from the fleet. In their place there developed a small group of independent pilots operating from land bases in Baja California and along the central coast of Mexico. The planes have been most effective during the spring fishery for yellowfin tuna in the Gulf of California. The spotter aircraft assist in two ways:

1. By scouting the general area for tuna schools and guiding the seine vessels toward worthwhile targets.

2. By detailed direction in laying the net around the school.

For their "spotting" services the vessels contribute five per cent of the catch from assisted sets. The consensus among vessel operators is that assistance from these aircraft is well worth the costs involved.

Trends in Fishing Success

Figure 1 is a plot of the ratio of the catch-per-day's-fishing by the original purse seine fleet (standardized) to the catch-per-day's-fishing for bait vessels

(also standardized). The quarterly values have been smoothed by threes and plotted for the period 1951-1959. For yellowfin tuna, the ratio remains fairly constant until 1956 and then turns sharply upward as the purse-seine catches rose. For skipjack tuna, a species taken less frequently by the seine fleet, an obvious upward trend is noticeable during these latter years although it is not so clear-cut. Also of interest but not well understood is the marked divergence of yellowfin ratio from that for skipjack beginning toward the end of 1954. No wide-spread technological changes were effected within the fleet until the 1959 season, whereas the catch-per-day's-fishing values began to climb in 1957.

Converted bait boats (Figure 2) began to appear in force in the purse-seine fleet during the 1959 season. For comparative purposes the catch-per-day's-

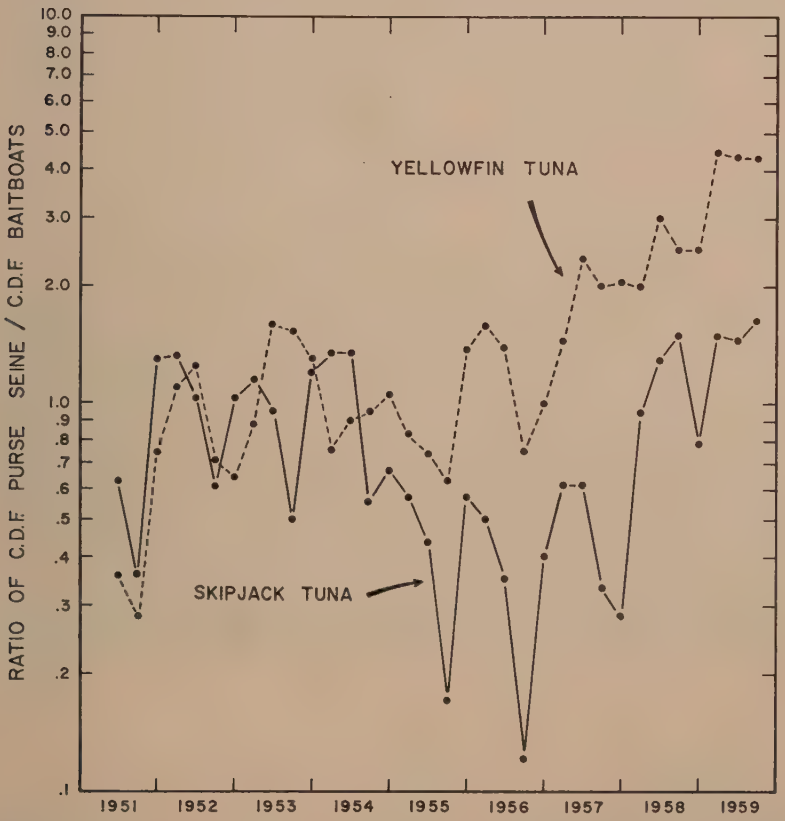

FIGURE 1. Ratios, for quarters of the year, of fishing success of purse-seine vessels, plotted for years 1951-1959. Five-degree areas where there were more than 20 standard days fishing each quarter, for each gear, were included. Equal weight was given to each five-degree area regardless of total catch of tuna in the area.

fishing for the first eleven conversions has been tabulated for 1958 and 1959 when they operated as bait vessels and for the subsequent period during 1959 and 1960 when they operated as purse-seiners. As bait vessels they fished 49 per cent of their time while at sea and caught an average of 7½ tons of tuna per day's fishing and as purse-seine vessels they fished 60 per cent of their time at sea and caught an average of 15½ tons of tuna per day's fishing.

FIGURE 2. Bait vessel with hull modifications and gear for tuna purse seining. (Courtesy *Pacific Fisherman*)

Changes in Oceanic Climate during Recent Years

The unusually warm water throughout the Eastern Pacific Ocean during the period 1957-1959 had considerable effect on the distribution of tuna catches (Alverson, 1960; Schaefer, 1960). Yellowfin tuna were noticeably absent from the central regions of the fishery. Skipjack tuna, and to a lesser extent yellowfin tuna, were found concentrated at the northern and southern ranges of the fishery. Bluefin tuna were abundant off Baja California and southern California

and were readily available to the purse-seine fleet. The shifts in tuna distribution have been favorable to the purse-seine fleet, which is equipped to harvest the yellowfin tuna appearing in quantity in the Gulf of California and the bluefin tuna that appeared off Baja California and southern California. The bait fleet fishing off Central America found very poor fishing for yellowfin tuna, and much of the fishing effort was concentrated in the distant grounds for skipjack off northern Peru.

SUMMARY

In the past several years there have been radical changes in the composition of the fleets fishing for tuna in the Eastern Pacific Ocean. Conversion of many of the bait vessels to purse-seine fishing has built up a large fleet of modernized seine vessels, many of which are capable of operating over the entire range of the fishery from California to Peru. Technological improvements in gear and fish handling have been responsible for a portion of the increase in seiner fishing success, the remainder being attributed to increased availability of the stock, in recent years, to this type of gear.

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Air-Bubble and Electrical-Field Barriers as Aids to Fishing

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The U. S. Bureau of Commercial Fisheries Research Station at Boothbay Harbor, Maine, has for several years conducted fishing gear experiments with new and unconventional methods for catching the Atlantic herring *(Clupea harengus)* that are canned as Maine sardines. Two such methods, called the Air-Bubble Curtain and the Marine Electric Fence, also show some promise of being useful for guiding and driving other species of fish. A considerable

amount of work has been done in the field of electrical fishing by private industry in the menhaden fishery during recent years, and as an adjunct to the herring work it has also been learned that some schools of large menhaden can be guided by means of air-bubble curtains.

Maine Sardine Fishing Gear

In order to appreciate the need for these methods in Maine, we must consider conventional sardine fishing gear and its limitations. There are two methods commonly used, the "weir" or "trap" method and the "stop-seining" method. Both types of gear are restrictive and confine fishing operations to very shallow waters and to areas of smooth bottom and low tidal flow. Combined with natural fluctuations in abundance, these restrictions often cause shortages in the herring supply resulting in cannery shut-downs and associated instabilities in the sardine industry.

A sardine weir is constructed of pilings that are driven into the bottom, over which cotton or nylon seine netting is stretched. A rounded heart-shaped wier is usually placed in a location where the water depth does not exceed six fathoms at high tide. A weir lead constructed in the same manner is run into the V of the body of the weir, usually extending out to it from the shoreline (Figure 4). The depth of this trap is limited by the length of pilings and stakes that can be obtained at minimum cost from nearby woods.

A stop seine is a straight piece of netting 7- to 10-fathoms deep with a lead line on the bottom and a cork line on the top. It is made up in 100-fathom lengths of nylon or cotton netting of ¾- to 1⅛-inch-mesh size (stretched mesh measure). Two to ten (rarely more) of these lengths are generally laced together to make a sardine "shut off." The stop seine is set behind a school of herring after the school has migrated into a shallow cove or up on to a smooth shallow beach. Seines of greater depth than 10 fathoms are not practical because the greater bulk of netting presents more resistance to tidal flow resulting in the raising of the lead line off the bottom and consequent escape of the trapped herring. (All of the Maine coastal waters are subject to rapid tide currents because of high tidal ranges.)

The Maine sardine fisherman is further restricted by the necessity of catching herring schools alive and holding them alive for periods of one day to several weeks. They are held in seine "shut offs" or in square enclosures of seine twine called "pockets."

The fish are held in these impoundments for periods of from 8 hours to several days, or in extreme cases, to several weeks until it is convenient for the sardine-carrier vessels, owned by the canneries, to pick them up. It is generally necessary to hold the sardines for at least one day to allow their intestines to clear out food and fecal matter which would spoil the sardine pack.

Stop-seine gear is very efficient in the respect that it catches one hundred per cent of the school, when schools can be located in suitable position. As effective as sardine weirs and stop-seines are, however, they have a common and serious weakness. This weakness is that both are passive and completely dependent upon the migration of the herring to shallow water fishing sites. During the months of late spring, summer, and fall, schools of herring usually migrate from the deeper waters of the open bays and oceans on what is generally believed to be a feeding migration up into the smaller coves and bays. It is during these migrations that the opportunity for catching the herring is

presented. Unfortunately, the schools often fail to run inshore far enough to be caught with stop-seines or weirs. Such schools can often be located, even during periods of great demand, lying in the deeper water of the larger bays and inlets along the Maine coast where they remain sometimes for periods of weeks but fail to make their expected migrations up into shallow waters. Thus, a situation of scarcity, while plenty of herring are under observation, frequently exists along the Maine coast.

Air-Curtain Trials on Herring

When the Maine herring gear project was started, it became obvious that there was a need to extend the fishery into deeper waters and into tidal currents. Also, a method was needed for sweeping the schools of herring that occurred beyond the range of seine gear to closer inshore areas where they could be captured. It was decided to try a string of air-bubbles discharged at the ocean bottom for this purpose. The most practical material for this air line was found to be flexible polyethylene pipe. This pipe was weighted to make it sink, drilled with holes of 36/1000 to 13/1000 of an inch diameter, and connected to an air compressor capable of supplying 130 cubic feet per minute (cfm) of air at up to 80 pounds per square inch pressure.

Figure 1 illustrates the method of setting the air-curtain pipe in the water. It is run off the reel at the stern of the boat. The lead weights sink it to the bottom and the air supplied by the compressor aboard the boat is discharged at the sea bottom from the small holes bored at 1-foot spacings in the pipe.

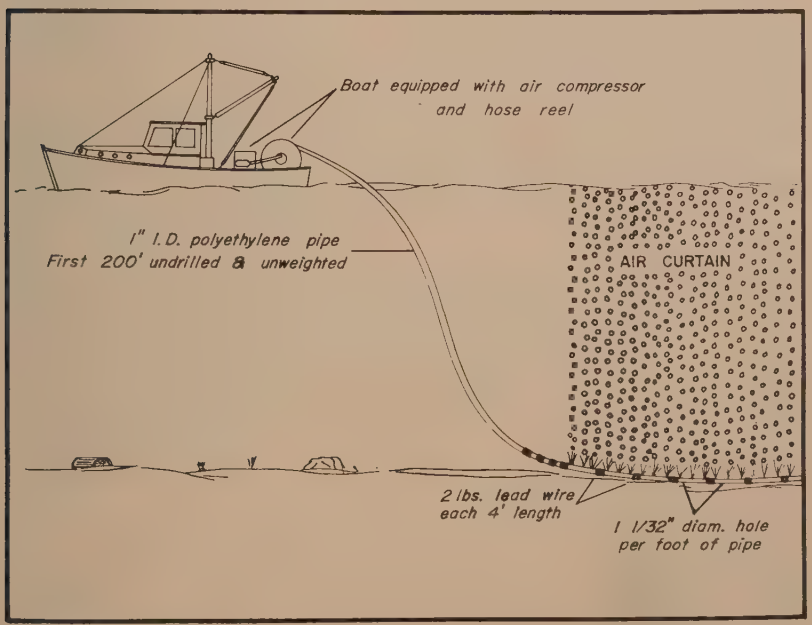
Boat equipped with air compressor and hose reel
1" I.D. polyethylene pipe
First 200' undrilled & unweighted
AIR CURTAIN
2 lbs. lead wire each 4' length
1 1/32" diam. hole per foot of pipe

FIGURE 1. Diagram of the air-bubble curtain as set from the stern of a boat.

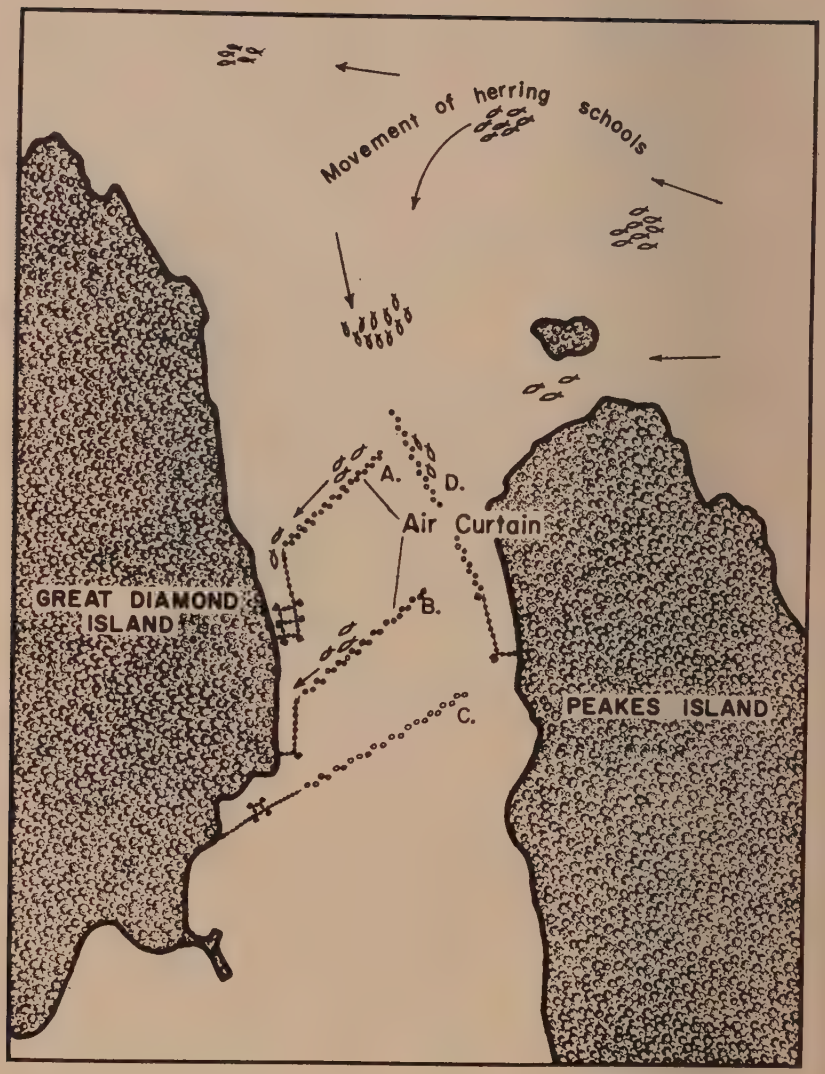

FIGURE 2. Diagram of air-curtain trials in Casco Bay.

The air-curtain gear was originally tested in West Penobscott Bay near Rockland, Maine. At this time, it was set up in the path of migrating herring schools that were observed to pass each night between two small islands. The first of these trials demonstrated that herring could be diverted from their normal migration pattern using the air-bubble curtain. Another trial indicated that the

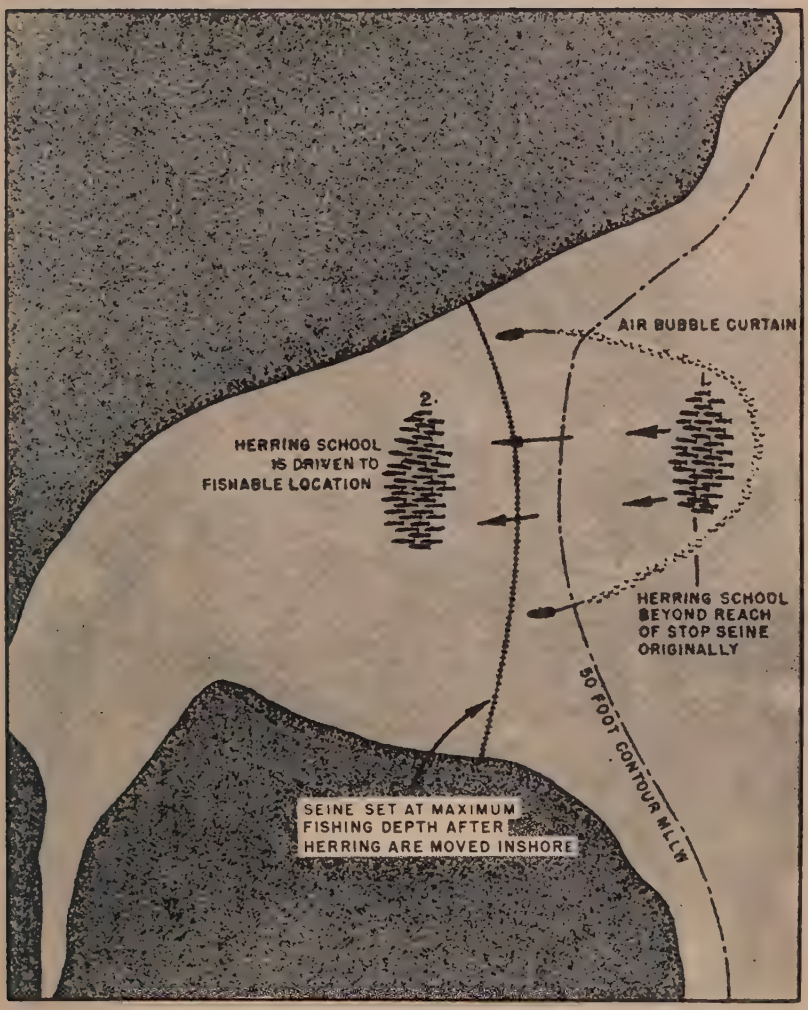

FIGURE 3. Method of driving herring school to fishing site.

schools could be stopped in their normal migration pattern and would react to the air curtain much as they react to a set of seine twine. That is, they would flatten against it and run along it toward one end or the other.

The site of the first trial of this gear in the commercial fishery is diagrammed in figure 2. Herring schools were found in this area to be moving down the channel between the two islands of Casco Bay, Great Diamond and Peaks Island, each evening shortly before complete darkness. They were remaining in the center of the channel away from stop-seine sites on each side of the

Diamond Island shore and Peaks Island shore. The air curtain was run out diagonally, shown in the diagram, in the several positions on several different nights. It was successful each time, when schools were known to be moving down the channel, in guiding the herring over to the seining sites at either shore where they were impounded in stop-seine gear.

In the seasons following these demonstrations, several sardine fishermen installed air-curtain gear of their own. Figure 3 and 4 show two applications of one fisherman's air-curtain gear. As mentioned above, herring schools often occur beyond the reach of the stop-seine twine. When this situation occurred

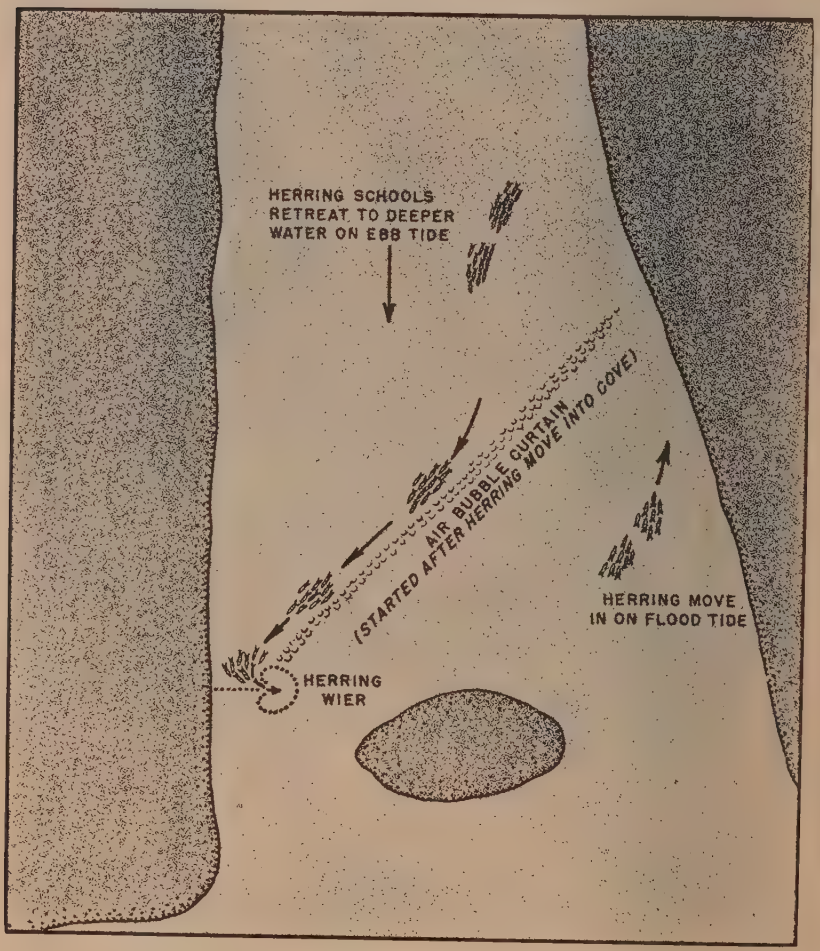
HERRING SCHOOLS RETREAT TO DEEPER WATER ON EBB TIDE
AIR BUBBLE CURTAIN (STARTED AFTER HERRING MOVE INTO COVE)
HERRING MOVE IN ON FLOOD TIDE
HERRING WIER

FIGURE 4. Air-bubble curtain used as an ultra-long deep-water weir lead.

repeatedly, at a location called Sandy Cove near Lubec, Maine, an air curtain was used to drive the herring school inshore where it could be impounded behind the seine.

The air curtain was looped around the school of fish, which is shown in position beyond the 50-foot contour. The plastic pipe was then towed slowly inshore by boats on each end, driving the herring school to within range of the stop-seine gear shown set at its maximum depth.

Another diagram (Figure 4) shows the same unit of gear as applied as a weir-lead in Cutler Bay, Maine, also near Lubec. In this application, the polyethylene pipe was laid on the bottom and left idle there until herring schools, moving in on the flood tide, had progressed to a position beyond the weir and beyond the polyethylene pipe. The air-compressing gear was then started, setting up the air-bubble curtain. At ebb tide, the retreating herring schools encountered the air curtain and were guided along it to the lead of the herring weir, from there they were diverted by the lead into the weir.

Menhaden Trials

Another aspect of the field testing of air-curtain gear of more concern to the Gulf and South Atlantic area is its possible application in the menhaden fishery. During the Bureau's association with the Smith Research and Development Company, subsidiary of the Fish Products Company of Lewes, Delaware, concerning electrical-attracting devices for herring, the company became interested in the possible use of air-bubble curtains in conjunction with electrical-fishing apparatus, as it might be applied to menhaden fishing. A unit combining the two methods was designed and the menhaden boat *Rappahannock* was brought to Maine for field trials of the unit on herring as a preliminary to trying the unit on menhaden. While searching for herring schools by aerial reconnaissance, on which to try the gear, schools of menhaden were located in Casco Bay near Portland, Maine.

The menhaden were observed to be moving in-and-out of Gun Point Cove in Casco Bay, so the air-curtain gear was set up as shown in Figure 5. Two 200-hundred fathom lengths of the air-curtain gear were laid down in a V-fashion so as to trap the retreating menhaden schools as they swam out of the cove at ebb tide. An electrode, similar to that used to assist in the unloading of purse seines in the menhaden fishery, was fastened at the apex of the V in a position about 40 feet from the boat. The object of this test was to determine: (1) whether or not menhaden schools could be guided by air-bubble curtains and (2) whether they would approach the electrode close enough, when guided in this fashion, to come under its influence and be drawn on into it.

Menhaden schools, starting in the position at the top of the diagram, progressed downward to position 1 as shown, then to position 2 where the indicated school moved down along the air curtain, avoided passing through it and gradually with some working in-and-out towards the curtain progressed to position 3. At this point, some of the fish were observed to move over to position 4 then to 5, which is about as close as the fish ever approached the vessel and the electrode assembly. In this position they milled around remaining 50 to 60 feet away from the electrode and nearly 100 feet from the boat until the test was ended due to darkness. It appeared that the fish were able to detect the presence of the large white boat in the water and also that as they

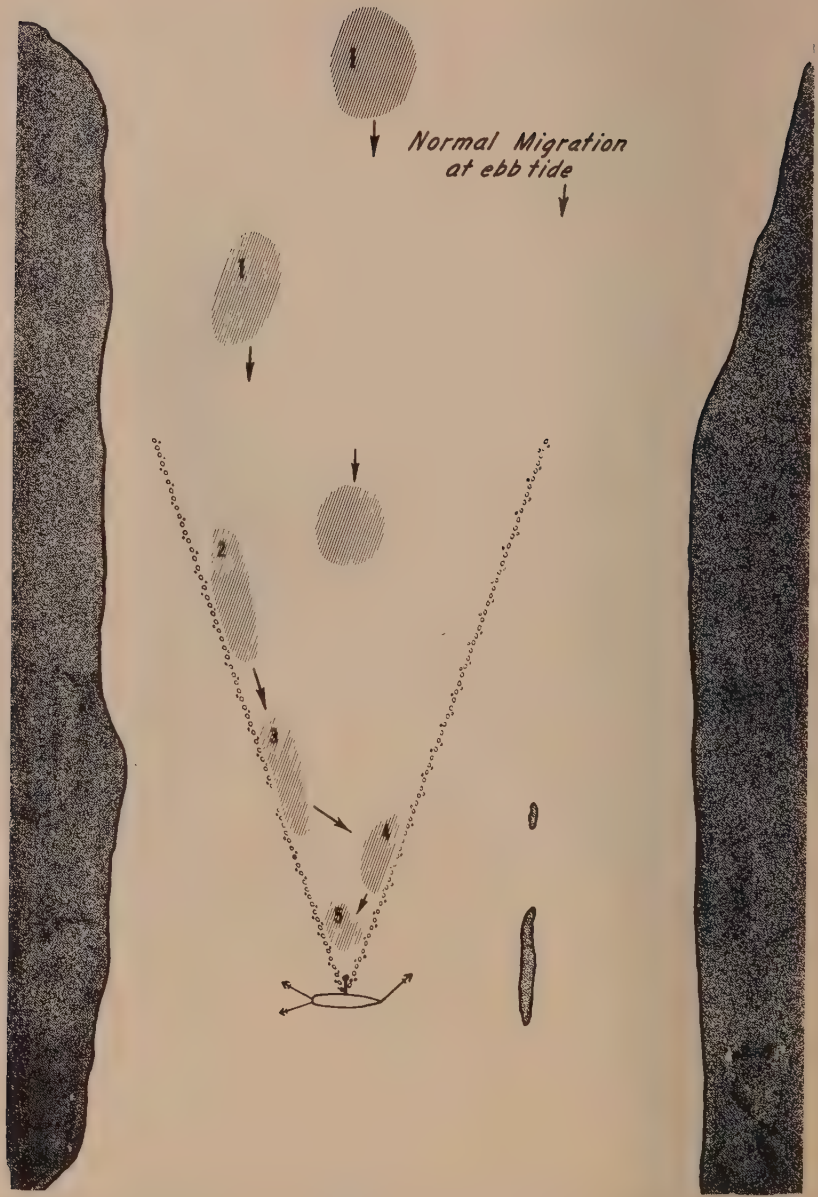

FIGURE 5. Air curtain and electrofishing trials on menhaden, Gun Point Cove, Casco Bay, Maine.

approached the tighter enclosure of the bubble curtain, they refused to progress any further toward the bubbles.

Menhaden schools were picked up again at a later date in Winnegance Bay of Casco Bay and trials were made of the possibility of enclosing and holding the schools within an *enclosure* of the air-bubble curtain. The 200-fathom lengths were laid out in this location much the same as they had been at Gun Point Cove except that they were spread at a wider angle.

This set is shown in Figure 6. The bubble-curtain legs were left in the wide-V position during a period of ebbing tide as menhaden schools were moving out of the cove in the direction indicated. After a number of the schools had entered the area between the legs, the ends were towed together forming the roughly squared-shaped enclosure. The schools were then watched from the air for a period of several hours to determine what their reaction might be when enclosed in this manner.

The movements of the school, in the lower right-hand corner of the diagram, was of particular interest. It moved up against the air curtain, backed off away from it, then moved up against it again, as shown by the arrows. This action was repeated several times while the school was being watched and it never did break through the air curtain. Neither, however, did the schools ever closely approach (that is, within 100 feet) the boat and electrode assembly shown at the bottom. None of these trials permitted a good test of the electrode assembly and the pulse generator unit attached to it because of the fear of the fish for the boat and electrode. Schools were held in this enclosure for a maximum period of ten hours.

Figure 7 represents, not an actual trial, but a proposal for a trial of air-curtain gear for fishing menhaden schools in the actual commercial fishing areas. The cross hatched area represents a section of coast line, the black representing the water and the small light patches schools of menhaden. In the area represented by the diagram, menhaden schools have been observed by fish spotters and boat captains to move in approximately the patterns indicated by the arrows. They move out of the bay and southward along the coast. Also, schools move southward from upper parts of the coast, running fairly close along the shore, usually within 3 miles of the shoreline. The air-bubble curtains would be laid in the positions indicated by 1 and 2. These curtains would be up to 1 mile in length and would utilize approximately 225 cubic feet of air per minute. The first objective, as indicated at position 1, would be to concentrate schools, particularly the small scattered ones that run down the coast in this area, so that they may be seined in this position. Such preconcentrating would be of value since, at many times, it is difficult to find a large enough school in position for making a seine set. If the results of the type of set, as indicated in position 1, show promise, then further work might be done to design some kind of holding device or trap at the apex of the curtains, as shown in position 2. Ideally, electrical driving and attracting gear would be used in this position to load the menhaden aboard the carrier vessels.

Marine Electric Fence

Another unit of gear was tried out last summer in the Maine sardine fishery, a device we call the marine electric fence. For a number of years some of the menhaden boats have been using electrified pump heads for easing the drying up and loading process when purse seining menhaden. One of these units was

supplied by the Smith Research and Development Company and was tried out by the Bureau of Commercial Fisheries during the herring season in the fall of 1959 for pumping herring in the same fashion. Only a limited success was experienced with this unit, and we were not able to demonstrate to sardine fishermen any great advantages that could be attributed to the use of it.

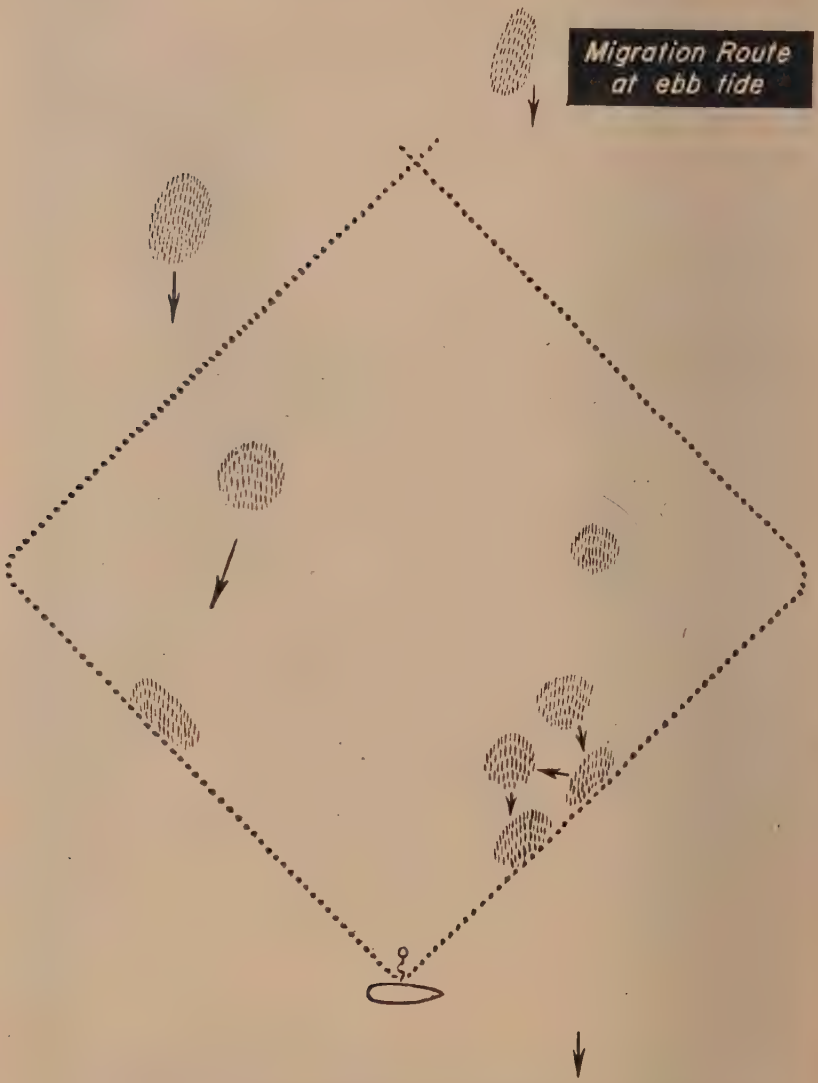

FIGURE 6. Holding trials on menhaden schools within an air-curtain enclosure.

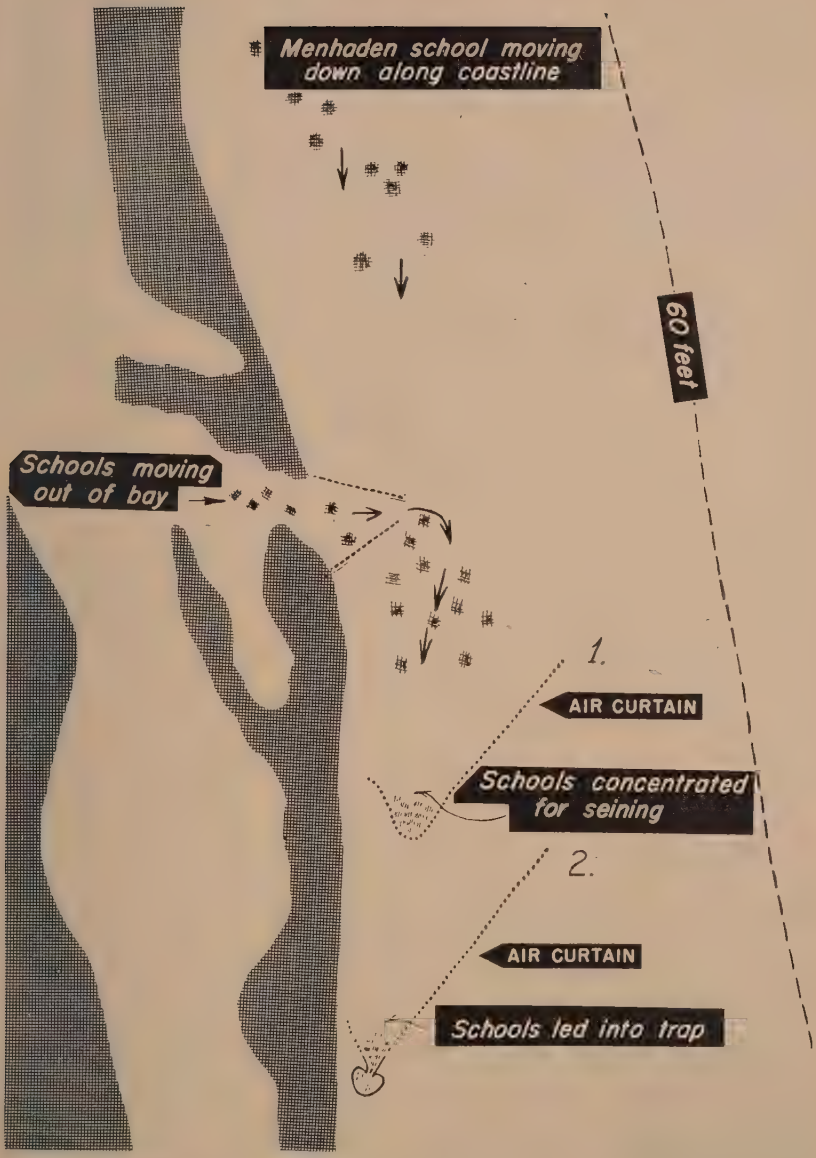

FIGURE 7. Diagram of a proposed trial of air-bubble gear in a commercial menhaden fishing area.

Although the loading process was eased, indications were that herring, killed or badly stunned by electrocution during the loading process, did not ingest the salt preservative as active fish do upon entering the carrier-vessel's hold and so, were in a less desirable condition for packing when delivered to the cannery. Also, the yield of valuable scales removed by the standard screening method appeared to decrease.

However, a similar unit has been used during the last two seasons for pumping herring aboard a vessel of a Maine fish meal and oil plant. The crew of this vessel reports that their unit is of considerable assistance in loading herring for reduction purposes. Also, progress was made in controlling the amount of electric shock received by the fish so that they entered the hold alive.

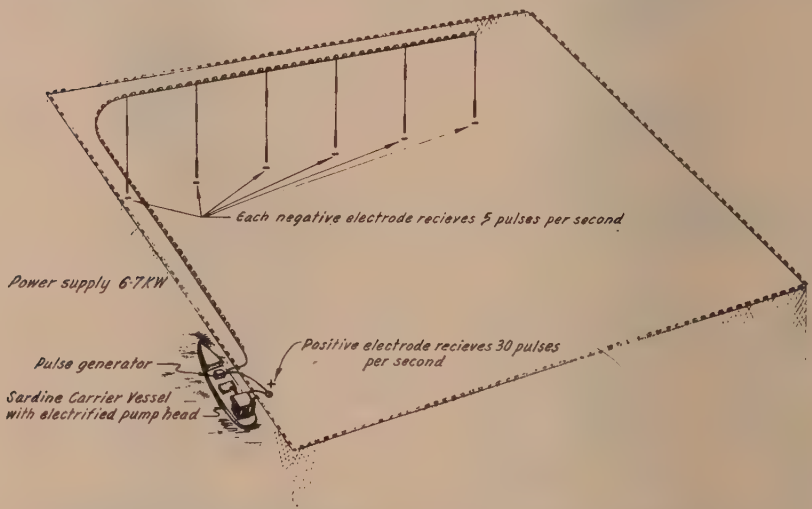
Each negative electrode recieves 5 pulses per second
Power supply 6·7KW
Positive electrode recieves 30 pulses per second
Pulse generator
Sardine Carrier Vessel with electrified pump head

FIGURE 8. Marine electric fence as tested in Maine sardine seine pocket.

Figure 8 is a diagram of a stop-seine pocket with a carrier vessel alongside it in position for loading. (Disregard for the moment the negative electrodes showing in the upper part of the pocket.) A small purse seine is normally set by hand inside this pocket. The seine is pursed by hand and the fish are drawn up by hand to a position adjacent to the carrier vessel, at which point the fish are pumped out by the standard fish pump method. (In the electrical fishing trials a positive electrode was placed at the pump head which was designed to attract fish to the pump head where they would be swept in by the water current and pumped into the hold of the vessel.) The hardest task connected with stop-seine operations is this hand purse seining of the sardine pocket. For this operation, *three* to *five* men are required, where other stop seining operations can be handled by *two* to *three* men. Also, since the work is done by hand, it requires a great amount of human effort and is a slow, laborious task.

The marine electric fence was designed and fishing trials were made to see if this pocket purse-seining operation could be eliminated by a method of

electrically *herding* the fish to the positive electrode and the pump intake instead of physically forcing them with the purse seine. As the positive electrode attracts fish within a limited range, so the negative electrodes are known to scare or repel the fish. This unit was, therefore, designed to use the negative repelling charge on the *opposite* side of the pocket from the fish pump intake, from which position it could be slowly swept toward the positive. In order to get the optimum effect from the negative electrodes they were not connected in parallel but the 30 pulse per second power supply was *split* among the 6 negative electrodes so that each successive pulse was discharged through a different succeeding negative electrode. Thus each of the six negative electrodes received 5 pulses per second of the 30 applied to the positive electrode. This system allowed the maximum pulse strength possible around each of the negative electrodes. The electrodes are 25 feet long and hang down in the water from the main power line which is also a floatline. They are spaced 12 feet apart giving a total length of 72 feet, including the repelling field.

The extent of the repelling field in this arrangement was expected to range 6 feet from the electrode. The field trials, however, showed the effective range to be much less. The herring, when pressed close with this device, approached to within 3 feet of the electrodes and passed easily between them.

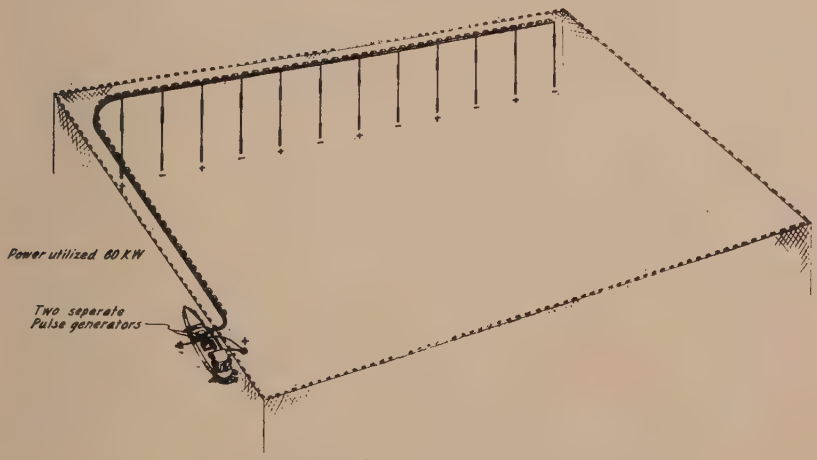

FIGURE 9. Marine electric fence No. 2.

So fence number 2 was designed as illustrated in Figure 9. There are 12 electrodes instead of six, labeled plus and minus. This unit operates on 60 pulses per second and will apply a full strength pulse to each electrode 10 times per second. As the applied pulses move down the line, each electrode receives successively a positive, then a negative charge. Thus an alternating current electric field, which also has a repelling effect on fish, is set up. This unit utilizes 60 kw of electric power, approximately nine times the amount used by the former model, which should give three times the effective range per field (as the strength decreases with the square of the distance from the electrodes.) The electrodes are spaced only half as far apart as before, which

will also increase the effectiveness of the unit. Notice that a separate unit is used aboard the carrier vessel for charging the positive electrode on the pump head. The negative side of the pump head unit is grounded to the sea bottom on the other side of the boat.

This new unit has not yet been tried out on fish but is currently being built at the Smith Research Company. Plans are to make fishing trials again in the 1961 Maine sardine season, when once again *It's Roundup Time in Maine.*

Fishery Products and Food Additives

L. M. Beacham

Division of Food, Food and Drug Administration, U. S. Department of Health, Education, and Welfare, Washington 25, D. C.

Many of us are convinced that our food doesn't taste like that which Mother used to cook. That view could be just the effect of comparing memories recorded in the technicolor of youth against the black and white of daily adult reality. But it is true that many of the foods that we now buy already prepared, processed, and conveniently packaged, contain ingredients that were never found in Mother's pantry. Often these ingredients, acting as antioxidants, emulsifiers, preservatives or in some other role, make possible, or are an inevitable accompaniment of, the modern form of the marketed food.

Such substances, now referred to as "food additives," have come into use in increasing numbers and in growing volume during the past two decades, until at last it was realized that a new law was needed to deal with them. Many of those already in use had not been studied sufficiently to make sure they were safe, because the old law did not require an additive to be proven safe before it was used in food. True, legal action could be taken if a food was found to contain any added ingredient that was poisonous or deleterious, unless such added ingredient was required or could not be avoided by good manufacturing practice and was covered by a tolerance, but the difficulty was that if a product was put on the market without adequate testing, the Food and Drug Administration had first to find out about it, then get samples, conduct long-term toxicity studies, and ultimately take legal action if the product was in fact found to contain a poisonous or deleterious component. Meanwhile, the public would be eating this particular food.

To improve this situation, in September, 1958, Congress enacted the Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act. The amendment provides a system for regulating food additives and it is designed to give the consumer better protection. With certain exemptions, it defines a food additive as any substance which may reasonably be expected to become a component of food or otherwise affect its characteristics, whether added directly or indirectly. No substance coming within the definition may be used unless a regulation has issued permitting and specifying the conditions of its use.

The definition exempts those substances which are generally recognized as safe by experts qualified to evaluate them. There are, of course, a great many

such substances, ranging from sugar and salt to much less familiar ones. While the law does not require us to do so, we thought that it would be helpful if we could identify at least some of the substances which we regard as generally recognized as safe—or GRAS, as they have come to be called—and thus exempt from the application of the Food Additives Amendment. With this in view, we published a substantial list of items in December, 1958, which we felt would be in that category; but because the Act refers to recognition by scientists qualified to evaluate the safety of food additives, we sent this list to over 800 scientists throughout the nation. We obtained several hundred replies and on the basis of these, we published on November 20, 1959, much of the original list in final form. Our experience with this special way of handling the first list of substances thought to be generally recognized as safe convinced us that it was not a very efficient way of dealing with the matter. We observed with satisfaction that this and other proposed GRAS lists that we subsequently published received quite wide publicity in trade and technical journals. In the future we will probably publish proposed GRAS lists, if any more are needed, wait a reasonable time for adverse comments, then make the list final if no significant exceptions are taken.

Incidentally, there has been some misunderstanding as to what is meant by "generally recognized as safe." A substance may in fact be a very safe one, but not be recognized as such simply because little or nothing is known about it in the scientific community. Information developed about it may have been guarded as a trade secret or may not have been published for some other reason. Even though a manufacturer has data which we acknowledge will show the substance to be safe, if scientists generally do not know anything about the substance, and are not acquainted with the data, it cannot be "generally recognized as safe." Such a substance is a food additive and requires a regulation to authorize its use.

Also exempted from the definition of food additives are those products for uses which had been given approval—or as the law terms it, "prior sanction"—by either FDA, or the Meat Inspection Division or the Poultry Inspection Division of the Department of Agriculture before the enactment of the Food Additives Amendment. Even though the law did not require it at that time, many manufacturers discussed with our pharmacologists their plans to incorporate new ingredients into their products and made such toxicity studies as were needed, waiting to market the food containing the new ingredient until they and FDA pharmacologists had agreed on the safety of the additive. Incidentally, a prior sanction granted to one firm for a specific usage of a product now applies equally to all others using the same product in the same way. We have not published lists of prior sanctions, with the exception of a few items in the packaging field, but if anyone believes that a prior sanction for a specific item has been granted and will advise us of the name of the firm thought to have received it, we will be glad to check our records to determine just what the situation is.

The third and last group of substances exempt from the provisions of the Food Additives Amendment are pesticide chemicals used on raw agricultural commodities. Such substances are dealt with by the Pesticide Chemicals Amendment of 1954.

In this connection many of you probably know that certain fishery products

have been classified as raw agricultural products under the latter amendment and under its authority tolerances of 5 ppm were established for chlortetracycline for whole, headed, or gutted fish, shucked scallops, and unpeeled shrimp, in fresh, uncooked, and unfrozen form.

Let me repeat, additives not covered by the above exemptions may be legally used in food only when authorized by specific regulation. In order to ease the period of transition, the Amendment provided that extensions up to March 6, 1961 could be granted to additives used before January 1, 1958, if no undue risk to public health is involved. At the present time a great many such substances are in legal use under extensions granted in conformity with this provision. The law grants no authority for administrative action to prolong these extensions beyond March 6, 1961, and it is the responsibility of all concerned to see that appropriate petitions for regulations are submitted in sufficient time for the necessary regulations to be issued before that deadline. This should be done not only for substances that are added directly to your food products, but also for those that may get in indirectly from contact by the food with the surfaces of equipment, belting, and the like, or by migration from wrapping and packaging materials, or in other ways.

The law and the regulations promulgated thereunder set forth in detail the procedure for submitting requests or petitions for approval of the use of food additives and empower the Secretary of Health, Education and Welfare to issue regulations authorizing such use and establishing tolerance limitations where these are necessary. This authority has been delegated to the Commissioner of Food and Drugs. The petition shall give full information about the identity, chemical properties, toxicity, and proposed uses of the food additive. In evaluating a food additive, we must have clearcut evidence of safety; we just cannot take chances in this field. On the other hand we do not want to require any unnecessary pharmacological work. We have urged those who have problems which appear to need pharmacological studies for their solution to discuss their planned work with our Division of Pharmacology before starting it. While our people sometimes advise that the program is not sufficiently comprehensive, there are other times when they have been able to conclude that not all of the work planned is necessary, or to advise other approaches that give promise of more effective results.

Our original intention was that a food additive regulation would specify the substance, indicate the reason for its use, limit the amount that could be present in the food, and would describe in every case a good method of determining whether the limitation had been met, through examination of the finished food product in the laboratory. In the case of many direct additives we still regard this as a sound minimum objective. We have found, however, that in some cases, even involving direct additives, limitations on the maximum amount that could be present were not necessary and in such cases we have concluded that the method of analysis of the finished foods need not have the precision that would be necessary where a tolerance limitation had been set. With indirect additives, such as those encountered in the packaging field, we have come to realize that it is impossible to expect the early development of analytical methods which would enable us to examine food products and determine how much of what components of the packaging material had migrated. We have considered other approaches such as that illustrated by the polypropylene

regulation issued several months ago. There we have based our regulatory control on the requirement that the polypropylene itself meet certain specifications. Elaborate tests have shown that if it does there will be no problem of migration. We hope that this approach and modifications of it will work satisfactorily in the development of regulations covering other packaging materials.

So much for the broad background of the requirements of the Food Additives Amendment, now let us consider some of the specific cases where it applies to fishery products. The fishery industry has not been behind other segments of the food industry in exploring and experimenting with the use of additives which offer promise of some desired technical effect. For example, EDTA, ethylene diamine tetraacetic acid, has been suggested for use in canned shrimp and canned crab meat to prevent struvite formation and darkening. A regulation establishing a tolerance for EDTA for this use is under active consideration at this time.

I referred earlier to the permitted use of CTC, chlortetracycline, in unprocessed fish, scallops, and shrimp under the provisions of the Pesticide regulations. There is also pending a petition for the use of this compound on fish fillets under the Food Additives regulation. Final action has not been taken on this petition pending the outcome of investigations designed to show whether or not such use of CTC actually inhibits decomposition or merely tends to mask its more obvious manifestations. In this connection I should point out that the law prohibits approval of a food additive if the proposed use of the additive would promote deception of the consumer or would result in adulteration or in misbranding of the food.

Of possible interest to your industry would be the permitted use of ammonium chloride in ice to keep the ice from shattering. This use in amounts up to 117 ppm is regarded as generally recognized as safe.

With many of your products you have problems of discoloration of the food during transportation and storage. A number of chemical substances have been and are used to overcome this. In addition to the EDTA mentioned above, there are citric acid, phosphoric acid, aluminum sulfate, and in some instances sulfur dioxide and sodium metabisulfite. These latter items have been recognized as safe as used in good commercial practice.

Various buffering and neutralizing agents are used, such as aluminum sulfate, aluminum sodium sulfate and aluminum ammonium sulfate. These too, are generally recognized as safe when used for this purpose in good commercial practice.

No doubt sodium benzoate and perhaps sorbic acid are sometimes used in some of your specialty products as preservatives. These too, are generally recognized as safe, although I should point out that their effectiveness as preservatives is often limited.

Many plants cook directly with steam or let the steam come in direct contact with the food in some other operation. Use of boiler compounds as rust inhibitors, antifoam agents, or for other purposes opens an avenue for indirect addition of food additives that must be taken into consideration. Nonvolatile materials such as trisodium phosphate, sodium hexametaphosphate, sodium hydroxide, sodium sulfite, sodium silicate and sodium aluminate cause no problem, but volatile chemicals such as morpholine, cyclohexylamine and octadecylamine require clearance. There are prior sanctions for 10 ppm of

morpholine or cyclohexylamine in steam coming in direct contact with foods, except milk. Octadecylamine is still under consideration.

Many fishery products are used for animal feed and it may surprise some of you to learn that the Food Additives Amendment applies equally to substances added to animal feed. This happens because the basic 1938 act defines food to include any article used for food or drink for man or animals and components of any such article. Thus, when a product within the definition of a food additive is incorporated into animal feeds the provisions of the Food Additives Amendment must be met. And here we have a double concern, for not only must the food additive be safe for feeding to the animal, but if it results in residues in the edible meat or milk of the animal this too must be taken into account.

It is possible that in your research laboratories you are experimenting with the use of additives other than those I have mentioned, which you feel will improve the character of your products. Let me urge that, unless these are generally recognized as safe by qualified experts, you also proceed now to acquire the necessary information regarding composition, toxicity, minimum amounts required, and analytical methods, to support petitions for food additive regulations authorizing their use.

Where there is any question of possible migration of additives into food products from wrappers, coatings, boxes, labels, or from any other source, we urge you to get the facts before continuing to use the particular articles. In many cases, you will undoubtedly find that the matter has been investigated by the supplier or original manufacturer and certainly if there are any specific questions about the law, do not hesitate to get in touch with us. We realize that in making this offer we probably are only adding to the heavy burden of correspondence which we have had ever since the enactment of this amendment. We will, however, do our very best to comply with each and every request for comment when we are supplied with sufficient facts upon which to base an opinion.

The Economic Potential of the Calico Scallop Fishery of the Gulf and South Atlantic With Special Reference to the East Coast of Florida

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THE LARGEST KNOWN SCALLOP BED in the entire world was recently discovered off the east coast of Florida by exploratory fishing personnel of the U.S. Bureau of Commercial Fisheries. First indications of the new seafood find were noted in January, 1960, during inshore explorations off Daytona Beach by the motor vessel, *Silver Bay*. Further explorations in April revealed that this bed extends from Daytona Beach south to Ft. Pierce—a distance of 135 miles. Commercial concentrations have been found over a 1,200 square-mile area. These same

Calico scallops have been found in commercial quantity off the coast of North Carolina, the upper west coast of Florida, and off the coast of Alabama.

The Calico scallop fishery obviously represents a potentially large commercial industry for the South Atlantic and Gulf seafood industry. What is the commercial potential and what problems are involved in developing this industry?

Let us proceed first with the commercial potential. We will confine our analysis to the scallop bed off the east coast of Florida. In early June, 1960, the *Silver Bay* made several demonstration trips for members of the seafood industry. Catches up to 20 bushels per one-half hour tow were made about 25 miles northeast of Ft. Pierce. Simulated commercial production, based on 16 experimental tows along the 20 fathom curve produced 135 bushels ranging from 1 to 13 per 30-minute tow for an average of 8.5 bushels or—about 4¼ gallons of scallop meats per drag. This production was realized with one 10 ft. dredge. The use of two dredges would normally double this rate of production.

There are two major problems retarding development of this potentially valuable fishery—developing means of mechanically processing the scallops and developing market outlets once this technological problem is solved.

The technological problem presently exists since hand shucking is slow because of small size, shape of shell, and the necessity of separating scallop meats from the viscera. There are several private firms presently conducting research on some mechanical means of processing the small Calico scallop. In addition, the Technological Laboratory of the Bureau of Commercial Fisheries in Pascagoula, Mississippi, is working on this problem. One type of mechanical oyster shucker is reported to open 250 bushels of scallops per hour but will not separate the meats from the viscera.

We have recently received word from a firm in the midwest that they have perfected a means of mechanically processing the Calico scallop. We don't know, as yet, any of the details of how this machine works and—for that matter—we don't know if it works.

Another firm here in Florida has recently developed a machine that will separate the muscle from the viscera at the rate of about one scallop per second. This amounts to about 5 gallons per hour. The beauty of this machine is that it is small and inexpensive and if the rate of processing needs to be increased, you need merely to install additional machines to obtain the desired rate. We have seen this machine in actual operation. It was recently taken aboard the *Silver Bay* by its inventors, Mr. Charles Renfroe, Mr. Lester Renfroe, and Mr. Ernest Wade of Jacksonville, Florida. The *Silver Bay* made a trip to the scallop grounds off Ft. Pierce and the machine was used to separate the muscle from the viscera. There is no doubt at all about the effectiveness of this machine—it will do the job. However, this machine is now dated, and the same inventors have come up with another machine that will process scallops at the rate of 1200 gal. per 8 hour day.

The next problem facing the industry will be that of developing markets for Calico scallops. This will not be easy. The scallop industry of New England is just recovering from an almost disastrous season characterized by record production, glutted markets and low prices. 1958 was a good year for the New England scallop industry, yielding nearly 19 million pounds of sea scallop meats. This was followed by a record production of over 24 million pounds in 1959 and the first five months of 1960 were even greater than for the comparable

period of 1959. Prices for scallop meats in 1960 reached the lowest point in many, many years. Florida buyers, for example, were quoted prices as low as 30 cents per pound, f.o.b. Massachusetts.

The severity of the depressed conditions in the New England scallop industry resulted in a joint industry-government promotional program beginning in August, 1960, and similar in scope to "Operation Shrimp" that was begun in the latter part of 1959. This joint program, as in the case of shrimp, resulted in moving the large excess stocks of scallops out of the freezers at the same time that greater than normal current production also was being sold to the trade.

The recent marketing problems of the New England Scallop Industry may actually be a blessing in disguise for future investors in the Calico scallop industry. Today, more people are eating scallops than ever before. This factor alone will make easier the job of introducing the Calico scallop to the consumer.

The logical question to be raised at this point is what marketing plans are being formulated for the future Calico scallop industry?

To begin with, it was felt that the first step should be to obtain as much publicity as possible on this new discovery, pointing out the commercial potential and, at the same time, the problems involved, in the development of this fishery. As of August 13, 1960, articles released by the Florida Development Commission alone reached over 2½ million readers of newspapers, business and scientific journals and various other publications. And this does not include those persons reached through the media of television and radio. Undoubtedly, the most important result of this publicity is that it challenged engineers throughout the country to solve the technical problems. As I have already mentioned, two different equipment firms in two entirely different parts of the country, Jacksonville, Florida, and Chicago, Illinois, have evidently solved this technological problem. Another important result of this advance publicity is that already there are many consumers anxious to try this "new delicacy from the sea."

Now, what else have we done, what are we doing, and what do we plan to do to create an effective marketing program necessary to develop this new industry? Before I proceed with these efforts, let me make it clear whom I mean by we. I mean industry and trade associations—I mean such organizations as the Florida State Board of Conservation, The Florida Development Commission, Florida Extension Service and the Bureau of Commercial Fisheries. All of these organizations have been active participants in this planned program:

1. Our home economist in Pascagoula, Mississippi, has been developing institutional, school lunch, restaurant and consumer recipes for Calico scallops. These recipes will, at the proper time, be distributed to institutions, public and private schools, restaurants, and food editors of the newspapers.

2. Working with the Florida Development Commission, we have already taken both black and white and color photographs of three different food dishes using Calico scallops in the recipes developed by our home economist. These pictures, along with the recipes and a fact sheet, will be distributed to the food editors throughout 15 southeastern and southwestern states as Calico scallops are introduced in these states.

3. We have been contacting the seafood processors throughout the country and keeping them current on the developments in this fishery. A large number

of these processors are most enthusiastic over the sales potential of this seafood item.

4. We have been contacting various frozen food distributors throughout our area and acquainting them with this new discovery. In many instances, we have arranged for future shipment of samples of this item for them to experiment with. As soon as industry is producing, we will make return visits.

5. We have been contacting food chain merchandisers with excellent results. We know that most of the food chain people contacted will do the merchandising job necessary to introduce this new seafood item to the public.

6. We have been contacting the media of radio, television and the newspapers and enlisting their future support in acquainting the consumer with Calico scallops.

7. Some of the restaurant associations have already been contacted and assurances of their future support received. This support will be in the form of distribution of recipes to member restaurants.

8. Arrangements already have been made for future distribution of recipes through the United States Department of Agriculture to institutions and private schools throughout the nine southern states.

9. We have discussed this program with personnel of the Florida Extension Service. Cooperation from this agency, with its 103 agents, in acquainting the public with Calico scallops has been assured.

10. Representatives of the Florida State Board of Conservation have been active in the development of this program. And those of you who know of the very fine work being done by their home economist also know that she will be instrumental in promoting these scallops once industry starts producing.

Now, I would like to discuss the methodology that we will use in the actual introduction of scallops to the institutional and consumer market. Again, bear in mind two things (1) This will be a joint industry-government program. (2) All of the agencies mentioned previously, and others, will be cooperating.

Perhaps the best way to illustrate the methodology would be to use a given city as an example. Since we now are here, let us use Miami as the example.

If there is any "certain key" to the success of this program, I would say that the educational media of radio, television and the newspapers will determine the relative speed with which this industry can be developed. We therefore will start with this media.

We will contact representatives of television and request placement of home economists on television during a certain period. We will do the same with representatives of radio. In the case of newspapers, we will approach the food editors of the *Miami Herald* and the *Miami News* with recipes, fact sheets and food photographs, requesting coverage in their food section. A picture of—shall we say—the Governor of the State of Florida tasting the first industry-produced Calico scallops should certainly make a good news item for these newspapers.

Assuming that we have been successful with the educational media, we then will contact the food chains requesting their assistance in introducing this item to the consumer. The fact that the educational media are cooperating is certainly an added inducement for the food chains and we would hope that they would follow through—not only by making the product available—but by advertising and merchandising the item.

Our next step would be to arrange for distribution of recipes through the Florida Restaurant Association to its members. Again, the cooperation of the educational media has whetted the appetite of the consumer to try Calico scallops in his or her favorite restaurant.

Through the U.S. Department of Agriculture, we would arrange for distribution of recipes to the various institutions which, of course, would find their way to such places here in Miami as hospitals, the University of Miami, sanitoriums, etc.

In the meantime, extension agents are also teaching the housewife how to prepare these scallops; they are promoting scallops on their radio and television shows, and they are writing about scallops in their newspaper columns.

We now can go to frozen food distributors and brokers and point out what is being done to promote Calico scallops. They, in turn, now are able to follow through and buy scallops with the knowledge that some of the groundwork has been laid to help them sell this item to retailers, institutions, and restaurants. And these brokers and distributors are the ones that bridge the gap between the producer and the retailer, and ultimately, the consumer. Industry, i.e., producers processors, brokers, distributors and retailers, are now in a position to form a coordinated advertising and promotional program for Calico scallops. The type of program developed by industry will determine the relative sales success of this item. Any efforts by U.S. Bureau of Commercial Fisheries personnel are meant *not* as a substitute, but rather to supplement and complement the efforts of industry.

As of this moment, we can sum up the history of the Calico scallop fishery in a very few words: discovery, technological development and some of the groundwork for a market development and market promotional program have all transpired in less than a year. Although a fishery with a short past, it is one with a long future.

A Progress Report on Experimental Fishing for Sardine-Like Fishes in the Gulf of Mexico

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THE GULF OF MEXICO pelagic schoolfish research, conducted by the U. S. Bureau of Commercial Fisheries, has been in progress for approximately three years. A summary of the first year of activities was presented to the Institute at the 11th annual session (Thompson 1958). Since that time, a number of interesting findings have been obtained, and it is the purpose of this paper to provide an interim report on the status of the research.

Midwater Trawling

A large share of the total effort expended on gear research throughout the world in the past ten years has been devoted to the development of commercially-operable midwater trawling gear. We have been able to profit

somewhat from the findings resulting from this considerable amount of work, but these findings have not been sufficient to solve our local problems. It has been necessary to depart from designs developed and successfully employed in other parts of the world including Canada (British Columbia), Europe, and elsewhere, to so much as "break the ice" in the capture of commercial-scale quantities of our pelagic species.

Gear modifications: To enumerate the research projects pertaining to midwater trawling gear and methods that have been undertaken on the international scene during the past ten years is beyond the scope of this report. A great deal of theory has had to be employed because only the sketchiest information has been available on the behavior of pelagic fishes or their reactions to trawling gear. Parrish (1959) summarizes the general consensus that pelagic school fishes tend to flee downward in front of an approaching trawl. To this we add our theory that most of these pelagic fishes are alarmed to a much greater extent by attempts to move netting over them than by attempts to slip netting under them. This has been substantiated somewhat by observing the reactions of scaled sardines, menhaden, thread herring, and Spanish mackerel during experimental lampara seining and while near-surface trawling with the two boat Larsen midwater trawl.

At present, the basic modification embodies net construction principles derived from underwater observations of trawls by the diving team of the Gear Research Unit at Pascagoula. These observations of trawl configuration at varying towing speeds strongly indicate that there is a widespread misconception concerning the role of headropes and footropes, and that the importance of determining optimum towing speed is often underrated.

Briefly stated, headropes and footropes are merely lines or cables extending from otter board to otter board. To these lines the net is attached or "hung," and from these lines the net is towed. The strain of the trawl is transmitted to the headrope and footrope and thence to the doors. An increased trawl strain or "drag" resulting from increased towing speed creates a backward sag in the net, bowing the headrope and footrope and changing the net configuration. Changes in net configuration, in turn, change the distribution of strain along the hangings or in the body. The greatest strain runs backward through the webbing from the point of tow—not crosswise with the headrope and footrope. This has been observed constantly in shrimp trawls where the meshes in the wings are stretched into elongated narrow diamonds whereas meshes in the top and bottom body sections are wide open. Using conventional headropes and footropes to take the strain, therefore, is somewhat irrational as it ignores the points and directions of strain.

To counteract this adverse net-sag/water-speed reaction we have designed trawls, the netting components of which are hung to exaggerated rib lines which are aligned along the paths of longitudinal stress. The four sides of the net are virtually V-shaped. The top, bottom, and sides are merely filled in with netting hung to a light line, which, although positioned as normal or customary head and footropes, take only the minor drag of the fill-in netting.

In the models presently under study the two lower wings are considerably longer than the upper wings. The fill-in netting of the bottom V extends well ahead of the forward edge of the "pseudo-headrope." The side V's are filled in wing-tip to wing-tip and the final effect is to create, as it were, a "topless net."

The theoretical assumption here is that a floor and side walls of netting can be positioned around schools of some species before the top-body panel of the trawl creates an extreme flight reaction.

In this manner we hope to overcome the problem of drastic change in net configuration, especially with the increased speed necessary in midwater trawling. Forthcoming experiments will employ these design characteristics combined with the use of knotless nylon netting—a combination which should enable trawling speeds above the present feasible limits.

The trawls are designed to measure approximately 60 feet square at the mouth, which we consider quasi-commercial in size with large Gulf trawlers.

Our experience, compatible with all other findings, has been that reliable telemetry is basic to successful midwater fishing. The equipment developed by McNeely (1959) has been used exclusively to date and has been very effective; however, some operational problems have appeared. Most serious is the frequent breakage of electrical conductors within the trawl cable. Second, telemetry is for otter-board level only and a number of discrepancies of trawl vs. board depth have been noted. These are within a magnitude of five fathoms, which is beyond acceptable tolerances. Present tests are employing pressure-sensing elements embedded in plastic which can be positioned at optional points along either the headrope or footrope, with separate trawl-to-boat conductors. Leakage of the water-tight housing has been minimal and occurred only when units were used at depths greater than 150 fathoms.

However, depth telemetry in itself is not the entire answer. The recently concluded studies by the Institut für Netz und Materialforshung, Hamburg, Germany, using a modified Atlas-Werke recorder with the transducer mounted on the trawl headrope (as reported on by Schärfe, 1960) appear to hold excellent promise for our regional studies, and we hope to test this or similar equipment in the north Gulf this winter. In essence, the recorded tracing shows what passes through the mouth of the trawl and the distance of the bottom of the trawl from the sea bottom.

General results: Most of the test fishing has been conducted in the Mississippi Delta area where schools are quite abundant in all seasons in depths of 10 to 75 fathoms. Successions of species seem to move through the area, and although it is now possible to identify some schools as to genus and species from fathogram profiles, trial tows have not been intended to be selective.

Highest catches during the tests have consisted predominantly of bumpers, *Chloroscombrus chrysurus,* and harvestfish, *Peprilus alepidotus,* species that could be considered commercially utilizable only for petfood or fish meal at the present time. Catches of 3000 to 7000 pounds per 60 to 80 minute tow with relatively unrefined gear have been made on two cruises.

Other species which have been caught at the rates of 1000 pounds or more per hour include thread herring *(Opisthonema oglinum),* scaled sardines *(Harengula pensacolae),* pinfish *(Lagodon rhomboides),* menhaden *(Brevoortia patronus),* and butterfish *(Poronotus triacanthus).*

The future: In the future, more emphasis in the pelagic, sardine-like schoolfish research will be placed on behavior studies of the species of interest. Actually, this should have been a starting point some three years ago, but at that time we had few ideas of what species might be present in large numbers or where and when they might be found. The tool we are putting into operation now is an underwater housing with a television camera used as a sighting device for a

remote-controlled motion-picture camera. This instrument will be attached either to a paravane or a remote-controlled sled. Positioning it at various positions around the mouth of the net will permit the collection of reliable information on evasive movements of most species. Some motion-picture footage that has been obtained by diver-photographers working around bottom trawls indicates that several species have little to fear from conventional gear. A good example is the carangid group (schools of jacks) viewed by divers which commonly approached a trawl apparently out of curiosity; swam around the cod-end, the body, the wings, and down into the mouth—moving as far as the throat or entrance to the cod-end; and then easily swam back out of the mouth. Observations such as these conjure up disturbing thoughts of the interpretations placed on quantitative and qualitative trawl sampling with gear used to date.

Some method of evaluating the efficiency of midwater trawling gear is desperately needed. The only feasible method seems to be repetitive observations with TV and motion pictures on escape behavior. With this information in hand, the 1000- or 5000-pound catch rates which we have experienced so often will be much more meaningful and gear development greatly simplified.

Other Gear Studies

Other gear studies pertaining to capture of pelagic species have included night light attraction and trapping experiments, lampara seining, and surface trawling. Night-light attraction studies have produced no significantly new information to date. A large number of species have shown positive attraction response, but insufficient time has been spent to obtain commercially-useful information on production.

A surface trawl has been tested as a scale model, rigged for shallow trawling. It was developed at the request of, and with suggestions from, Leon Kenny and Heber Bell of the St. Petersburg area, who hope to apply this fishing method to Spanish mackerel when extremely murky water conditions are present in the Florida Bay. This project has been called off for the present, but the gear appears to have some promise for anchovy fishing in the northern Gulf and will be test fished next summer.

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THURSDAY—NOVEMBER 17

Chairman—THOMAS D. MCGINNIS, *President, Virginia Seafoods, Inc., Irvington, Virginia*

Status Of Researches On Oyster Diseases In North America

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NEEDLER (1931) FIRST CALLED ATTENTION to disease of oysters and the related mortalities in Malpeque Bay, Prince Edward Island. This disease has come to be known as Malpeque Bay disease (Logie 1958). Although studied over a long period, less is known about Malpeque Bay disease and its effects than is known about any of several diseases studied much later. Prytherch (1938, 1940) believed that *Nematopsis ostrearum,* a gregarine described by him, was highly pathogenic to oysters and that mortalities in Louisiana and Mobjack Bay, Virginia, were caused by this protozoan. Prytherch's belief in the pathogenicity of *Nematopsis* has not been corroborated by later studies, but his work served to focus attention on the highly important field of disease researches. Mackin, Owen, and Collier (1950) described *Dermocystidium marinum* and initiated a long series of studies of this pathogen. Andrews and Hewatt (1957), working at the Virginia Fisheries Laboratory, made significant contributions to the study of this parasite in the period from about 1952 to the present. Ray (1954) working at Rice institute and at the Grand Isle Laboratory, contributed his diagnostic technique and other outstanding researches.

Mackin, Korringa and Hopkins (1952) suggested that Hexamita might be a factor in epidemics in America, and Stein, Denison and Mackin (1960) experimentally infected *Ostrea lurida* with Hexamita (and perhaps other disease-producing organisms) but were unable to do the same with *Crassostrea gigas.* Davis and Loosanoff (1955) described a fungus disease of oyster larvae and Mackin and Loesch (1955) reported on a Haplosporidian parasite of Bucephalus in oysters. In 1957, Haskins and associates began studies of mortalities due to disease in Delaware Bay and were soon joined by a number of other workers on the middle Atlantic coast. At this time, diseases associated with these mortalities are being studied closely. Mackin (1960) reported on "Mycelial disease" of oysters on the Gulf Coast, and added data on several other new parasites and diseases of problematical nature.

It is the purpose of this paper to discuss some of the parasites and diseases mentioned above with the intention to point out progress of researches and problems solved and to be solved. The latter are in the majority. No attempt is made to exhaust the field, but only to discuss those features of most importance at this stage of the studies.

Malpeque Bay Disease

Needler (1931, 1941), Needler and Logie (1947) described a disease which struck oysters in bays of Prince Edward Island, Canada, in about 1915. These were pioneering studies of disease of oysters in America. Although these authors and other Canadian workers have never solved the problem of etiology their work is nevertheless distinguished because of the demonstration that disease-restistant strains of oysters may be developed through exposure to disease. According to Needler and Logie the advent of disease coincided first with the advent of oyster farming and second with imports of oysters from the United States. Planted oysters died over two or three years time and cumulative mortalities reached ninety per cent. Oysters affected were thin and emaciated and sometimes had yellowish pustules and abscesses. Epidemics appeared successively in various bays of Prince Edward Island, but required a period of many years to affect all populations of the Island. Recovery in Malpeque Bay, the original focus of disease, required about thirteen years. Although local stocks apparently became largely immune to attack after that time, the introduction of foreign stock from time to time showed that the disease was still endemic and is still so today (Logie 1958).

Logie (1958) described extensive experiments testing for development of resistance of oysters to Malpeque Bay disease. These indicated that the development of resistant strains occurred under stress of natural selection. This was a noteworthy achievement and points the way to the most promising of the methods in controlling other diseases of oysters. But if the Prince Edward Island experiments are any indication, this will be a very slow and painful method of rehabilitation.

Certain epidemiological data presented by Logie (1958) indicate that Malpeque Bay disease may in fact be two diseases or possibly even more. Separation of mortality peaks into winter-spring and late summer peaks may mean that there are two corresponding diseases. Resolution of the problem of etiology in the case of the Canadian diseases becomes most important.

Needler (1941) showed that prior to the onset of disease, said to have begun in about 1915 in Malpeque Bay, the oyster industry had already undergone severe reduction. The year 1882 showed a peak production of more than 50,000 barrels of oysters; the production was cut in half the following year, and never again attained the peak production. By 1894 production was down to less than 20,000 barrels. By 1915, when Malpeque Bay disease was said to appear, the oyster industry was down to about 4000 barrels, or about 8 per cent of peak production. By 1918 the industry in Malpeque Bay disappeared, presumably because of disease. Needler thinks that the decline prior to 1915 was due to overfishing of natural reefs. After decimation of these natural reefs the oystermen turned to oyster farming and introduced the disease with seed. However. the data do not indicate that the disease was a new introduction. Here are the reasons why this is so:

(1) The natural reefs, said to have been decimated by over-fishing, were abandoned one by one over the years. They did not rebound when abandoned, which they would have if they had been healthy reefs.

(2) The sparking of the epidemic in Malpeque Bay could just as logically have been due to infection of highly susceptible imports with a local disease as to infection of local oysters by an imported disease.

(3) In fact the description of the beginning of the epidemics by Needler and Logie (1947) suggests that it was the imports and not the locals which were first decimated by disease. They stated that "In 1915 large numbers of oysters were found dead or dying in the central part of Malpeque Bay, in the area where the imported oysters had been planted. In 1916 the mortality spread throughout the bay and its immediate tributaries." The imports were, therefore, highly susceptible to the disease and were wiped out first. It appears odd that imports bringing in a disease from an endemic area should themselves be victims of a disease to which they should have been largely immune. This violates all concepts of epidemiology. The imports should have survived to become the back bone of a new industry. But they did not. They may have survived just long enough to cross breed with the natives, thus producing new crops of susceptibles. The thirteen years which elapsed before the industry revived could have been the time required to eliminate the introduced susceptible strain of oysters. This does not invalidate the concept of the development of resistant strains as described by Logie (1958). Indeed it makes the case stronger.

It should be observed also that severe epidemic disease followed the introduction of the practice of making concentrated plantings in small areas. It is the opinion of the author that this one factor has made those areas where crowded planting is the rule the areas of most intense development of oyster disease (Louisiana and Virginia). This is a concept which should be closely studied: Has modern planting method itself precipitated the most acute crisis in oyster production ever observed?

***Mortalities associated with* Haplosporidium spp.**

Excessive loss of oysters in Delaware Bay became apparent in the spring of 1957 (Haskins, 1959). In a six week period in April and May, 35 per cent to 85 per cent of planted oysters died, the number depending on location and origin of the oysters in Delaware Bay on the New Jersey side. Losses continued in 1958, 1959, and 1960. In each year the mortalities were in two periods, the first in the late winter and early spring, the second in late summer and fall. Mortalities extended to the seed bed area in the fall of 1958 (Haskins 1960). Generally speaking, Haskins' reports indicate that, so far as disease is concerned, the spring mortality period is about as severe as is the summer-fall period.

Seiling studied mortalities in Chincoteague Bay (see report by Fred Seiling in Haskins, 1960, 1960a). This bay has a history of recurrent mortalities going back to the mid-forties, and perhaps earlier. Seiling reported mortalities at nine stations in Chincoteague Bay and on Virginia seaside in the period from March, 1959, to January, 1960. The average for native oysters was 27.6 per cent (tray oysters) and for "control" imports was 7.5 per cent. Peak mortality at all nine stations was in the May-June period, but there was also a September-October peak at several stations. Andrews and Wood (in Haskins, 1960) also reported that appreciable mortality occurred on the Virginia seaside in the May-June period, but not in the summer-fall period. Andrews (personal communication) reported that the seaside May-June mortality was repeated in 1960, with identical timing with the 1959 losses.

Haskins (1959) reported the finding in diseased oysters of a new organism, termed in manuscript reports the "MSX" organism. This was determined by Mackin to be one of the Haplosporidia, probably genus *Haplosporidium*, (see Haskins 1960). This organism has been consistently reported to be associated with the summer-fall mortalities in Delaware Bay, and appears to be present

in the spring period of mortality but in reduced incidence. Haskins (1959b, fig. 2) showed that weighted incidence of this organism in tray oysters (Cape May area) rose steadily from July to November, 1959, thus correlating with the summer-fall mortalities, but the same diagram showed that it had almost disappeared by April of 1959. These data were also presented by Canzonier (in Haskins 1959a) in table form. Haskins (1959b, 1960) showed that the mortalities continued into 1959 and 1960, with about the same pattern of peaks. If the data on weighted incidence have continued in the same pattern in 1959 and 1960 as was established in 1958 the spring mortalities have a different etiology from that of the summer-fall peaks. A careful study of all distributed data shows that exact calculations of the incidences of the "MSX" organism have not been presented by Haskins and associates in the critical period of the spring mortalities (about late April to late June), or for the earlier winter-spring mortalities. Haskins (1959b) believes that the winter-spring mortalities result from infections picked up in the preceding fall which so weaken the oysters that they die under stress of winter hibernation. There appears to be a better alternative explanation, namely that "MSX" is not responsible for the winter-spring mortalities but that some other pathogen is responsible. This could be any of several known to be in the area, (excepting *Dermocystidium marinum*).

"MSX" organism is in the Chesapeake Bay area where it is now spreading slowly (Wood in Haskins, 1960; Andrews, Wood and Hoese 1960). The organism appears to be in fairly heavy concentration in the Mobjack Bay-lower Chesapeake Bay area, where heavy losses have occurred in the past, and where steady increase in mortality has occurred in 1960. "MSX" appeared in heavy concentration after June, 1960. Hampton Roads also had heavy losses in the summer of 1960.

The consistent mortalities of oysters in seaside bays concentrated in the May-June period led to studies of epidemiology and the parasites concerned. The Maryland-Virginia seaside mortalities differed from those of the Delaware Bay Cove in that spring peaks stood alone and were not followed by the summer-fall peaks (see Andrews and Seiling, in Haskins, 1960). A species of Haplosporidium, similar to the "MSX" is associated with these seaside mortalities. Haskins and Stauber believe that this Halosporidium is "MSX" but it differs in that spore stages are prominent in sections, whereas in "MSX" spore stages may not have been observed at all. Andrews and Wood (1960) believe that this Halosporidium is a different species from "MSX." The author concurs in this opinion, which is based on observed differences in the parasite and on the epidemiological differences which have been worked out by Drs. Andrews and Wood. Thus there may be two species of Haplosporidium, overlapping ecologically, in the Mid-Atlantic area, one concentrated in the lower reaches of the large estuaries, the other in the smaller sea-side bays behind the barrier islands.

Additionally, Mackin (1960) reported an organism causing "amber disease" in Louisiana oysters which may be related to the Haplosporidia, and there is another species in Louisiana associated with short term spring mortalities which perhaps should be included in the genus Haplosporidium. The Haplosporidian parasites appear to form a group of considerable importance in oyster mortality and within the next ten years it is believed that the group will be studied intensively.

Haskins (1959b) assumed that "MSX" was new to Delaware Bay, basing his belief on the fact that his studies showed that the parasite apparently

appeared first in a central area of the Delaware Bay Cove, and spread from there to outlying areas. This is what would have happened if the parasite developed a cyclic epidemic wave after a period of subsidence, and may not constitute evidence of a new introduction. A study of oyster production in Delaware Bay shows that there were earlier cyclic declines in oyster populations. Indeed, the present decline appears to have begun in about 1954 rather than in 1957. It forced attention in 1957 but, unless one mortality-producing agent suddenly dropped out of sight and another took its place in 1957, a most unlikely event, "MSX" and/or other pathogens, began the present epidemic wave in 1954. If this parasite was new in 1957 the pathogen suddenly displayed a tremendously accelerated capacity for dispersal, since it is now known to exist in the lower Chesapeake and in various sea-side bays up at least as far as the Great Bay area. One would have to assume that (1) the "new" organism spread from the Delaware Bay Cove to all these outlying areas in a few years time, or (2) it was present in these other areas in the past, but never penetrated to Delaware Bay until the mid 1950s, a concept difficult to believe when one considers (a) all the multiple opportunities for distribution of a pathogen in Atlantic coastal waters, and (b) the history of variable production, and overall declining production in Delaware Bay.

The studies of Pixell-Goodrich (1915) on *Haplosporidium chitonis* are pertinent in this matter. Lankester reported the presence of *H. chitonis* in English waters in the mid 1890s; Pixell-Goodrich, beginning about 10 years later, searched for the parasite for four or five years before finding it. When found it was abundant in an area near the Plymouth Laboratory. This suggests that there are periods of cyclic abundance in these parasites, alternating with periods of scarcity.

Infection experiments with "MSX" (Scheltema, in Haskins, 1960) have not been successful because *Dermocystidium marinum* invaded the control and experimental tanks and produced such severe mortality that interpretation of results was complicated. Andrews and Wood (personal communication) have tried to infect oysters with "MSX" but results of these studies have not been reported to date.

Hexamitiasis

Certes (1882) recorded *Hexamita inflata* from the digestive tract of oysters, *O. edulis*, and noted that the flagellates were true parasites since they reproduced in the host. Orton (1924) recorded flagellates which probably were Hexamita from diseased oysters in England. Richardson (1939) recorded Hexamita from Canadian oysters, *Crassostrea virginica*. The latter author associated Hexamita and a ciliate with mortality in a few oysters. He used the generic name Urophagus interchangeably with Hexamita. Mackin, Korringa and Hopkins (1952) named Hexamita as the etiological agent in "pit disease" of Dutch oysters and called attention to intracellular stages. Stein, Denison, and Mackin (1960) showed experimentally that *Ostrea lurida*, dying with heavy Hexamita infections, could be used to transmit lethal disease to uninfected oysters; but that *Crassostrea gigas* was not affected. It was uncertain in these experiments whether or not the actual etiologic agent of disease was Hexamita, or whether there was an association of Hexamita with some other disease agent which latter was the actual lethal agent. At the present time the most pressing problem related to Hexamita is to resolve this question. There are three schools of thought so far as Hexamitiasis is concerned. Tenets of these

are as follows. (1) Hexamita is a saprophyte or mild parasite, and the association of the flagellate with mortalities of oysters is due to the universal distribution of the flagellates. They are always ready to attack dying oysters in the late winter or spring. The intracellular stages, according to this theory, are phagocytized leucocytes. (2) Hexamita is a parasite but is not of itself sufficiently pathogenic to destroy oysters. It may finish off weakened oysters; weakness is assumed to derive from cold or other adverse chemical or physical conditions, or from some other disease. (3) Hexamita is a highly pathogenic parasite. It can of itself kill oysters, and extensive mortality is attributed to it. The intracellular cells are developmental stages, and the disease attacks oysters when they are alive and in excellent condition.

Each of these positions has supporting data. In support of the theory that the Hexamita of oysters is a saprophyte is the fact that trophozoites do not ordinarily appear in oysters until they are dead or moribund. Smears of stomach contents or gill of apparently healthy oysters may show light infections with trophozoites but rarely are they found in numbers. The supposition that "intracellular stages" are phagocytized leucocytes rests solely on a resemblance of some intracellular stages to leucocytes.

The concept that Hexamita is a weak parasite, and is effective in destruction of oysters when host restistance is reduced by adverse environmental agencies, rests on somewhat firmer ground. Mortalities laid to Hexamita predominantly follow cold winters, occurring when oysters are subjected to low temperature sufficient to affect ciliary activity. In the case of *Hexamita salmonis* attacking trout, young trout in hatcheries are particularly subject to mortalities, especially after handling, and after transportation in confining containers. Oysters in holding basins in Holland, when artificial low temperatures were maintained, and where the water was recirculated, had heavy mortality not equalled, so far as known, on bedding grounds in the same general area. Experimentation on the effect of Hexamitiasis on *Ostrea lurida* showed that excessive mortality occurred only when the temperature in aquaria was held below 10°C. The dikes in which *O. lurida* are grown in the South Sound area in the state of Washington, and where "Hexamita" epidemics occur, depend for their usefulness on concentration of oysters in very large numbers in very small areas. This overcrowding appears to be a prime factor in development of epidemics in that area.

Those data supporting the concept that Hexamita is a highly pathogenic organism may be summarized as follows:

a) The fact that Hexamita is associated with extensive mortalities of oysters is itself the strongest evidence of pathogenicity. The association is not local: the syndrome accompanying the mortalities, which includes the production of trophozoites as an end phase, occurs in Australia, Holland, the Pacific Northwest, the Atlantic East Coast, and rarely, the Gulf Coast of the United States.

b) Several other species of Hexamita are considered by principal researchers to be pathogenic (McNeil et al, 1941; Moore, 1923, 1923a; Davis, 1926). McNeil et al produced disease by transmitting the parasites. In fact, the group is basically parasitic, and the "freeliving" forms are actually the questionable ones. There is evidence that the trophozoite may be the motile distibuting stage of a life cycle in which tissue-infection cells make up the effective parasitic stage.

c) The intracellular stages seen in oyster tissues, epithelium of the gut, Leidig cell tissue, gonad, and other organs of oysters are developmental stages

of Hexamita. The resemblance of some of these stages to oyster leucocytes is superficial and most developmental stages bear little resemblance to leucocytes. It is admitted that these stages may be another organism, but if it is then this other organism is quite definitely tied to Hexamita, not only in the Hexamita of oysters, but in the Hexamita of trout *(H. salmonis,* Moore) as well. It also appears wherever in the world that the trophozoites appear. The close resemblance of the aflagellate stages in the oyster to the developmental cycle as worked out by Moore (1923a); and Davis (1923, 1924, 1926) for *H. salmonis* is remarkable and extends to basic cytological features in mitosis. It is known (Swezy, 1915) that *Hexamita nodulosa* of amphibians also develops multinucleate stages closely resembling the multinucleate stages of certain so-called Haplosporidians and to those in oysters associated with Hexamita.

d) Experiments by Stein, Denison, and Mackin (in press) transmitted intracellular and tissue infecting stages along with the Hexamita trophozoites. It is obvious that a disease was transmitted which was accompanied by a complete syndrome of the Hexamita cycle as worked out by Moore and Davis. It remains to be shown that some obscure disease, rather than Hexamita, was the lethal factor.

e) Extensive field studies in Puget Sound have shown that live, apparently healthy oysters show all stages of development of disease, including the end stage, the trophozoite.

f) Cold of itself cannot be the cause of mortality in those cases where mortalities are associated with both cold and Hexamita. Roughley (1926) showed that the disease was not actually tied up with extreme cold, when studying the Australian "Winter Disease." Those oysters subjected to most intense cold failed to die, while those subjected to slightly higher temperatures died. The author has studied oysters from Australia dying of Winter Disease and they have the same Hexamita syndrome as do American and Dutch oysters, Stein et al (1960) showed that controls subjected to the same low temperatures as were experimental oysters failed to die in comparable numbers. *Crassostrea gigas,* subjected to both cold and Hexamita infection, failed to die. Conversely, it is apparent that Hexamitiasis is a winter-spring disease just as *Dermocystidium marinum* is adapted to high temperature. Most disease-producing organisms are environmentally controlled to some extent as are free living organisms.

These differing view points all have merit. But it is obvious that those most closely associated with experimental studies favor the thesis that Hexamitiasis is a winter-spring disease of *Ostrea spp,* but it has not been demonstrated that *Crassostrea spp.* are also affected.

Sheltema (see Haskins 1960b) inoculated Hexamita into oysters held at low and high temperatures and failed to get a mortality difference between the controls and the experimental oysters. It was not stated how the controls were prevented from becoming infected or indeed whether they were or not. It was stated in the report by Haskins that Scheltema failed to confirm the works of Stein, Denison, and Macklin (1960). Since he was not repeating experiments of these authors (he used a different host and completely different methods) it is not clear in what respects he failed to confirm work of these authors.

Dermocystidium marinum

D. marinum was described by Mackin, Owen, and Collier (1950). Since that time extensive and intensive studies of this organism have been carried out.

Mackin (1951) studied histopathologic effects and suggested methodologies of study in that field. Since the appearance of the original description of the disease and its causative organism, many studies of distribution, epidemiology and pathogenicity have been carried out. The disease caused by *D. marinum* affects oysters from Delaware Bay (Anonymous, 1958) to Mexico (Mackin, 1960a). The range is not continuous, since certain areas appear to be free of the parasite (Virginia seaside). Areas such as Aransas Bay, Texas, appear to have an increasing incidence (Hofstetter and Hefferman, 1959). In the more northerly part of the range, *D. marinum* disappears from the oyster populations in winter, but reappears in the summer to produce epidemics. This indicates that an overwintering stage (the hypnospore) exists. In the Gulf States, temperatures may not be low enough to eliminate the parasite, and in mild winters considerable mortality may result from epidemics. The principal effect of mild winters is to insure severe epidemics the following summer and fall. Low salinities and effective flushing of estuaries tend to decrease incidence of the fungus.

Diagnosis of the disease has been simplified through the studies of Ray (1954), making possible extensive studies of distribution, development of epidemics, and pathogenicity. Experimental studies by Mackin, Ray, and Andrews and Hewatt (See Mackin, 1960a) have established that *D. marinum* is highly pathogenic, and the disease caused by this fungus is a major threat to oyster production within its range. In the Virginia-Chesapeake Bay area (Andrews and Hewatt, 1957) a summer epidemic may destroy fifty percent of oyster populations. In Louisiana (Mackin, 1960a) oyster plantings may be virtually destroyed in a single summer.

Other Diseases

Mackin (1960) reported on several parasites and diseases not heretofore known. At the present time none of these seem to be major causes of mortality, but this may be because they have not been tested in the ecological areas best suited to them. The "mycelial" disease for example is now known to be widely distributed in the Gulf, Atlantic, and Pacific Northwest. There are indications that it may at times be destructive in Louisiana and Texas. The causative organism of "amber disease" appears to be rare, but may be rare in the Louisiana area where it was first observed, but common in some as yet unknown area where ecological conditions favor the parasite. The author has observed a species of *Dermocystidium* in Australian oysters, and a plasmodial parasite in *Crassostrea gigas* from Japan. These parasites must sooner or later be studied in more detail.

Problems of Disease

The pressing problems confronting students of oyster diseases are many and difficult. There are no short term solutions for these problems. The major ones are as follows:

(1) Before serious work can be undertaken, the kinds and relationships of the organisms parasitizing oysters must be resolved. It is unfortunate that most parasites causing disease in oysters seem to be aberrant types and belong to little-known groups of fungi, *(D. marinum),* protozoa, ("MSX" and related species), or bacteria, ("Mycelial disease"). Failure to properly solve the problems of etiology is a solid hindrance to further studies. We are much too prone to believe that basic taxonomic studies can be relegated to the background while

studies of "practical" nature are pursued. This belief has delayed the solution of some problems of Malpeque Bay disease for more than thirty years.

(2) Solution of the problems of epidemiology is the essence of studies of disease. This means the study of those ecological conditions which augment disease or control its incidence, hosts and reservoir hosts, transmission agencies, parasite physiology, distribution, form of epidemics and many others. Management of oyster crops depends upon accumulation of data of this kind in sufficient amount.

(3) Studies of life cycles of parasites probably should be included as a part of epidemiology. But the obvious paramount importance of these studies justifies singling them out. If counter measures against disease become possible, it will be because there are "weak points" in the parasite life cycle which make it vulnerable to artificial control.

(4) The search for races of oysters resistant to disease, and the management of oyster plantings to further development of resistant populations is at least one area in which progress may be made in spite of lack of specific basic knowledge in taxonomy and life cycles (example: Malpeque Bay disease). It is evident that development of resistant races for specific disease has more chance of successful accomplishment than any other control method. Here also is a type of study in which collaboration of planters and scientists in the studies is feasible and probably necessary.

(5) It is predicted that in the near future highly artificial methods of oyster production must replace the bulk methods now in use in the United States. Control of disease may be possible under artificial conditions, such as pond and tray culture, while it may not be possible under the planting methods now used. Part of the increasing toll of disease may be due to heavily crowded plantings, constant reintroduction of large numbers of susceptible oysters to areas of endemic disease, and repeated reintroduction of disease by exotic oyster populations. In anticipation of the day when the industry will be dependent on the development of artificial culture methods, researches in this field should be pressed even stronger than is now the case. Tray culture is not new, and neither is pond culture, but all too little is known of the problems involved.

(6) Studies of natural biological controls for disease may possibly produce results of value. It is believed that this is a rather slender thread considering that its application would depend on finding natural controls existing in some unexplored part of the world. Since most parts of the world are totally unexplored for the disease-producing entities found in American waters, it would involve much spade work.

(7) Chemical control is considered much too risky to be attempted. Even if chemical control, selective of the parasite could be found in laboratory studies, large scale treatment of estuarial waters is not advised because all factors of the environment may not be explored in the laboratory. It is believed that chemical control is on its way to reduced use in agriculture because of hazards of modern highly toxic compounds.

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Delaware Bay Oyster Mortalities

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Abstract

In approximately six weeks in the spring of 1957 over 50 per cent of the oysters planted on leased grounds in Delaware Bay died in an epizootic. The kill was most intense in the center of the leased grounds and decreased in intensity with distance from this center. No unusual mortalities were detected in the eastern planted areas nor on the seed beds in the Upper Bay. By fall of 1958 oysters were dying in the Upper Bay seed beds and in all areas on the planted grounds. Seed oysters planted in the spring of 1958 had an average mortality of 52 per cent by that same fall. A year later the minimal kill of this population was 80 per cent.

A new sporozoan has been identified as the causative agent in this epizootic kill. Experimental studies of several imported stocks have shown differences in susceptibility to the pathogen and have demonstrated the seasonal patterns of kill.

Rehabilitation of Disease-Depleted Oyster Populations in Eastern Canada

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INTRODUCTION

In Eastern Canada, oysters, *Crassostrea virginica*, Gmelin, occur in those portions of the provinces of Prince Edward Island, New Brunswick and Nova Scotia bordering the southwestern Gulf of St. Lawrence.

In 1915 oysters started dying in large numbers in Malpeque Bay, Prince Edward Island. Mortalities fanned out from an apparent epidemic centre and soon involved Cascumpeque and Bedeque Bays. By 1920 the fishery of these waters was prostrate. Subsequent investigation, ten or more years after the subsidence of spectacular mortality, suggested:

(1) that in infectious, epidemic disease was involved;

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(2) that mortalities exceeded 90 per cent of pre-epidemic stock;

(3) that survivors were wholly or partly resistant and bred similar progeny;

(4) that the progeny became fully resistant (i.e., less than 10 per cent per year died) in about thirteen years from the first disease mortalities.

In the next twenty-five years this disease destroyed all the oyster fisheries of Prince Edward Island. Perhaps the most interesting outbreak was the one affecting Hillsborough Bay and it tributary rivers, commencing in 1935, because it was observed from its onset and because resistance was studied and attempts were made at rehabilitation. Observations disclosed a spreading epidemic of much the same nature as in Malpeque Bay, except that mortalities reached or exceeded 95 per cent. In Johnston River, a small tributary, a relatively large number of resistant Malpeque adults were planted to act as brood stock in assisting rehabilitation. This had no apparent effect, the development of full resistance taking thirteen years, as in Malpeque Bay. In a further effort at rehabilitation, resistant Malpeque Bay spat were sold, in comparatively small numbers, to growers in Hillsborough Bay and the principal tributaries. The fishery recovered to its pre-epidemic level in ten to twelve years, as compared to the twenty years required in Malpeque Bay. It is uncertain whether this was accomplished by direct survival of these spat to market size or by their spawning of resistant young or by a combination of these two.

The causative organism of these epidemics was not discovered.

Pertinent papers are those of Needler (1931, 1936 and 1941), Homans (1937, 1938 and 1939), Fraser (1938), Richardson (1938), Needler and Logie (1947) and Logie (1958). The last two are the most comprehensive.

From 1947-50 and again from 1953-55, the senior author studied model or miniature epidemics in small lots of mainland oysters placed in the waters of Bideford River, tributary to Malepeque Bay. From these experiments it appeared:

(1) that the causative organism was still present in Malpeque Bay waters;

(2) that mainland oysters were susceptible;

(3) that, with few exceptions, mortalities followed a characteristic pattern of a one-year lag, presumably for development of the disease in the oyster, followed by heavy mortality reaching 95 per cent of the original number in three years and a probable terminal value of 99 per cent; the heaviest rate of mortality occurred in the third year of exposure and reached 75-80 per cent.

It is probable that all Prince Edward Island epidemics conformed closely to this description. The apparently increasing mortality in successive outbreaks was more probably the result of closer observation than of increasing death rate.

In 1955, oysters commenced dying in mass numbers in various waters of New Brunswick and Nova Scotia. This epidemic is still advancing, the sole area of any importance not yet clearly involved being Bras d'Or Lake, N. S. Mortalities follow the same pattern and reach the same intensity as described for Prince Edward Island.

The normal oyster fishery of the mainland is relatively large, that of New Brunswick in particular being two to three times that of Prince Edward Island. Rehabilitation of the fishery in these provinces was therefore a pressing problem. The urgency was increased by another consideration. Returns from the oyster fishery provided in many cases an essential segment of the income of people

in a chronically precarious financial state. Rapid restoration of the fishery was therefore an urgent socio-economic measure.

Even considering its poor success in Johnston River, the most promising technique at the time was the transfer of resistant Prince Edward Island adults to disease-depleted mainland waters to act as brood stock. In orderly scientific procedure it would have been necessary to discover the answers to the following questions before massive transfers took place:

(1) Was this the same disease as in Prince Edward Island?
(2) Would Prince Edward Island adults survive in the mainland waters?
(3) Would they spawn?
(4) Would their progeny be resistant?

However, because of the urgency of the socio-economic problem, preliminary search for these answers and large-scale rehabilitation transfers went on almost concurrently.

MATERIALS AND METHODS

Commencing in 1956 and continuing every year thereafter, two lots of 300 Prince Edward Island oysters were held in trays in several locations in mainland waters. Mortalities were regularly observed in these and in comparable lots of native and of Bras d'Or Lake oysters held as controls.

Commencing in 1957 and continuing into 1960, large numbers of adult Prince Edward Island oysters were transplanted to the principal diseased areas of the mainland to serve as brood stock. In all, some 4 to 5 million oysters were so transplanted.

Commencing in 1957, mortalities in tray lots of spat annually produced in diseased areas were observed. Since 1958 two controls have been employed:

(1) Malpeque Bay spat (presumably resistant);
(2) Bras d'Or Lake spat (presumably susceptible).

In addition general observations have been made of the numbers of spat and small oysters appearing on natural and artificial cultch in the diseased areas.

RESULTS

As already stated, the pattern of mortalities in mainland epidemics conformed in virtually every case and every particular with that established as characteristic of epidemic disease in Prince Edward Island.

The introduced oysters did live and did exhibit the same degree of resistance as in Prince Edward Island.

They did spawn. It should be stated that 1958, 1959 and 1960 were good spawning years and that 1959 was phenomenally so.

Large numbers of spat and of year-old oysters appeared in the diseased areas, but spat caught on artificial cultch and held on trays in these areas has died heavily, showing no clear disease resistance whatever. Similarly spat and small oysters picked up from around the shores died when held on trays.

DISCUSSION

The identity of mainland and of Prince Edward Island oyster diseases cannot be established by reference to the causative organism, since this has not yet been clearly identified. However, adherence to the characteristic mortality pattern everywhere and the similar resistance of Prince Edward Island oysters in Prince Edward Island and in mainland waters are together taken as the best

available evidence that all epidemics are due to the same cause. It should be pointed out though that this is an inference from the data rather than a definitive statement (Logie, 1958).

The lack of resistance in spat produced in mainland waters after transfer of Prince Edward Island brood stock is disconcerting to the whole concept of rehabilitation by this method, although it has been pointed out by Drinnan and Henderson (1959) and by Drinnan (1960) that it conforms to the precedent established in Johnston River in 1939 et seq.

No completely satisfactory explanation of this phenomenon can be advanced, but Drinnan (1960) has speculated about it. Spat produced locally on the mainland now could be a mixture of three crosses:

(1) native x native;

(2) native x P.E.I. transplants;

(3) P.E.I. transplant x P.E.I. transplant.

Good reasons exist for suggesting that the first two of these should be highly susceptible and that the third should be highly resistant. Because of the paucity of surviving native adults demonstrated by searches so far, it was considered that progeny produced after rehabilitation transfers would be dominated by the third parentage listed above. In view of the data now at hand, it appears probable that somewhere in the diseased areas large enough stocks of surviving natives exist to exert a dominant influence on the genetic composition of the spat. This thesis is barely tenable in some cases, but it is nevertheless the only one consistent with the facts. Its authenticity should be tested by:

(1) searching for the postulated stocks of native parents;

(2) destroying them when found;

(3) saturating further with P.E.I. parents;

(4) continuing trials of spat survival, both in trays and on natural cultch.

In the meantime, judgment of this method of rehabilitation should be withheld.

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Recent Advances in the Control of Shellfish Predators and Competitors

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The purpose of this article is to describe briefly several methods of control of shellfish enemies that either came into practical use during recent years or are on the threshold of being employed on a large scale by shellfish industries.

As is well known, the methods of controlling shellfish predators and competitors may be of three basic types, namely, biological, mechanical or chemical. Biological methods, being more natural than those of the other two categories, are preferable in many respects. However, in aquatic environments they are difficult to develop and, perhaps, even more difficult to execute. An example of this was when a ciliate, *Orchitophyra stellarum*, was discovered in gonads of male starfish, *Asterias forbesi*, which were made sterile by the activities of this parasite (Piatt, 1935). Unfortunately, regardless of persistent efforts, we failed to spread the infection among starfish kept in the laboratory aquaria and tanks or in Long Island Sound.

Mechanical methods have been mainstays of shellfish cultivators for many years. Most of us are familiar with starfish mops and dredges, drill traps and, more recently, suction dredges that are in use in this country. The principles of these methods have already been described (Galtsoff *et al.*, 1937; Galtsoff and Loosanoff, 1939). In Europe, for over a century, several types of fences have been in use against crabs and rays. All these methods are partially helpful but none is adequate in itself. As a result, to cite one example, the recent prevalence of drills in Long Island Sound compelled the oyster industry to give

up virtually the entire area of Milford Bay, where only a few years ago highly productive beds existed. Almost total extermination by starfish of the extremely heavy 1958 oyster set in Long Island Sound is another example of the inability of oystermen to protect their crops with the methods presently available.

Since it has always been realized that mechanical methods of control are expensive and usually only partially effective, the possibility of using chemical substances to combat starfish and predatory snails, such as oyster drills, was considered on many occasions. During the early 1930's biologists experimented widely with copper sulfate to eradicate starfish (Galtsoff and Loosanoff, 1939). A few years later an effective chemical method, consisting of spreading quicklime over starfish-infested bottoms, was perfected at Milford Laboratory and has been used ever since by several oyster companies in Long Island Sound (Loosanoff and Engle, 1938). This method, unfortunately, has its limitations also, principally because quicklime becomes slaked upon contact with sea water and, therefore, soon loses a great deal of its efficacy.

As often occurs in nature, an oyster or a clam faces its enemies from the very beginning of its existence. Predation begins as soon as the eggs are shed and continues through larval, juvenile and even adult stages. In addition to direct enemies, such as plankton eaters are to early stages of developing bivalves, and as, later on, bottom predators, such as gastropods, starfish, crabs and the flatworms, *Stylochus,* are to recently set bivalves, competing organisms are often of paramount importance. We are all familiar with tunicates, *Crepidula,* barnacles, hydroids, and algae, not to mention mussels, which often set so heavily that they smother recently set oysters by competing with them for space, food and oxygen. Some of these forms, including barnacles and tunicates, act as direct enemies of oysters by eating their larvae and, also, as competitors of more advanced stages when living in the same environment. Because direct and indirect enemies of shellfish are important in mariculture, control measures should be developed for both groups.

As far as I am aware, there is virtually nothing new to report as to recent achievements in the field of biological control of shellfish enemies. Several laboratories are experimenting along such lines, but these experiments have not progressed far enough to give us any assurance that successful methods will be developed. At our laboratory, on the suggestion of our British colleagues, we experimented with the Sun-star, *Solaster papposus,* brought from the waters of New Brunswick, Canada, as a form that would attack and feed upon our common starfish, *A. forbesi.* The results were discouraging because usually the latter acted as the predator.

Contrary to the lack of progress in biological methods, a new mechanical method, which seems to show considerable promise, is now under trial at Milford Laboratory. It consists of burying drills under a thin layer of bottom material (Loosanoff and Nomejko, 1958). Laboratory experiments demonstrated that when buried at a depth of 3 centimeters, approximately 40 per cent of drills, *Urosalpinx cinerea,* could not reach the surface and died. If covered with a layer 6 cm deep, about 92 per cent of drills perished. Later, we discovered that the method is also quite effective against starfish. When buried under 1 inch of mud these pests died within 24 hours and in sand, within 48 hours. Only about 10 per cent of starfish buried with one or two rays protruding from sand could emerge, while the others died and decomposed within three days. F. Mansfield & Sons Company of New Haven is presently under contract with

our Bureau to develop mechanical details of an underwater plow to be used for extermination of drills and starfish on bottoms composed of comparatively soft material (Figure 1).

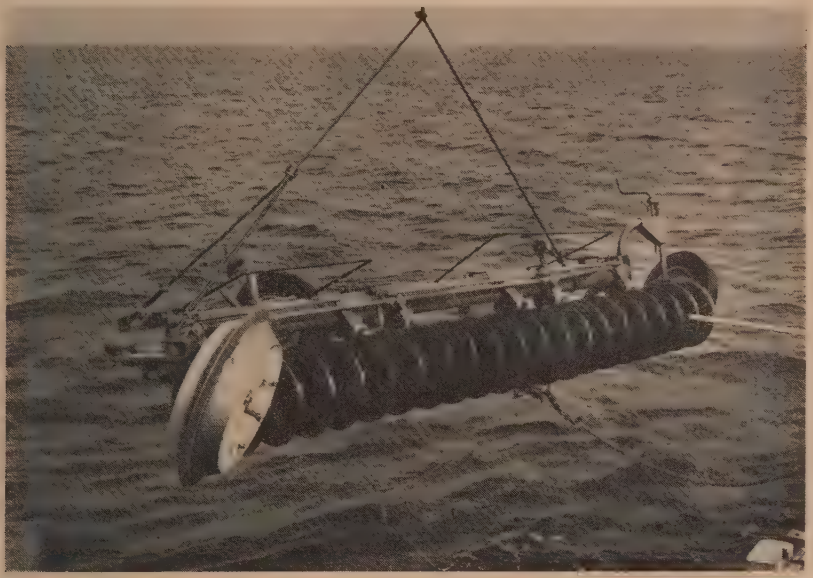

FIGURE 1. Underwater plow, used in control of oyster enemies and competitors, ready to be lowered.

The underwater plow method also appears to be promising in controlling the common mussel, *Mytilus edulis*, which at times occurs in a thick layer covering oyster beds of Long Island Sound. We have reason to believe that the same method will be effective against *Crepidula*, another important oyster competitor.

Probably the greatest progress in recent methods of controlling shellfish enemies has been made in the use of chemicals, especially insecticides. Many of these methods, several of which were developed at Milford Laboratory, are comparatively new and some of them are still undergoing a series of trials. In general, the use of chemical control measures can be discussed in two ways. The first consists of mentioning each enemy separately and then describing the method that is effective against it. The second approach offers, first, a general description of the method and then the names of all enemies that can be controlled by it. For this discussion the second approach has been selected as being more convenient and less time-consuming.

In controlling undesirable aquatic forms chemicals can be used in several ways. They may be (1) dissolved in water; (2) spread over large areas of the bottom as a thin layer which will repel enemies, such as drills, starfish, crabs, etc., or kill them or their larvae upon contact; (3) used in so-called barriers, or belts, made of chemicals mixed with materials of an inert nature, such as sand or fragments of old oyster shells, and laid as a continuous band to surround

the oyster bed so that enemies, such as starfish and drills, will be stopped before penetrating into the protected area; (4) combined with shell material of living oysters, old oyster shells, or other spat collectors to make them either unsuitable for the existence of such forms as sponges, worms, and other shell dwelling organisms, or to prevent their fouling with tunicates, hydroids, barnacles, *Crepidula,* worms, algae, and others; (5) combined with shells of dead oysters, or other materials used as cultch, to repel drills or to kill larvae of other undesirable forms, such as flatworms, *Stylochus,* which may set on these shells and attack oyster set. A modification of the latter method may consist of using chemicals which will not only repel enemies but, simultaneously, attract oyster larvae to set in larger numbers on the specially-treated collectors; and (6) incorporated as poisons in foods that will be eaten by shellfish predators, such as horseshoe crabs, crabs, prawns, rays, drumfish, and others.

In addition to the above-mentioned uses, another method of employing chemicals may be suggested. It would consist, in general, of placing on an oyster bed, certain selected compounds, incorporated in organic solvents, that would gradually ooze into the water and create near the bottom, for desirable periods, light concentrations of chemicals that would be, nevertheless, strong enough to eliminate fungus, bacteria, hydroids, algae, and, perhaps, crustaceans and worms, without seriously endangering commercial mollusks or affecting their food value.

Water Solutions

Water solutions of chemicals should be used only under controllable conditions. Therefore, their use may be practical, as a rule, only in small volumes of water, such as laboratory and hatchery troughs and tanks, or in small lakes, ponds, claires, and dikes. Solutions can also be used advantageously for dipping into them, during transplanting operations, dredge-loads of oysters infested with boring sponges, worms, barnacles, etc. In still another case, placing infected bivalves in certain chemical solutions may free them of some internal parasites. We shall consider each of these uses separately.

Solutions of chemicals can be advantageously employed in controlling various forms of zooplankton, especially crustaceans of the sub-class Copepoda, which sometimes interfere with culturing of larval mollusks or invade mass cultures of phytoplankton, such as *Chlorella,* where they multiply rapidly and soon render the cultures worthless. In the past such invasions presented us with rather serious problems since it was virtually impossible to destroy the copepods, chiefly because of the viability of their eggs. Recently, however, we have been using a number of chemicals to prevent the invasions or terminate them (Loosanoff, Hanks and Ganaros, 1957). Several insecticides, which are known under the trade names of Guthion, Dipterex, Parathion, Lindane, TEPP and, more recently, Sevin, a carbamate, have been used for these purposes. The method is simple but effective. For example, in a 1.0 part per million solution of Guthion all crustaceans are killed within 2 hours at room temperature. Complete mortality is also caused by 0.05 ppm of Guthion or Lindane at the end of 20 and 53 hours respectively. The concentrations used, fortunately, do not noticeably affect the normal existence of algal cultures nor do they affect bivalves or their larvae which are fed treated *Chlorella.*

One of the most common offenders in hatchery trays and troughs is a bottom amphipod, *Corophium cylindricum,* which seriously interferes with recently set young clams, *Venus mercenaria.* This crustacean can also be easily exterminated

by subjecting it for several hours to a solution of any one of several of the above-mentioned insecticides at a concentration of 1.0 ppm or even lower.

Sometimes, for example, during our experiments on propagation of oysters conducted in an artificial pond on Long Island, large numbers of free-swimming crustaceans become a problem because they compete with oyster larvae. We determined that a concentration of approximately 1.0 ppm of TEPP (tetraethyl phyrophosphate) killed crustaceans without causing serious injuries to oyster larvae. Many bottom crustaceans present in the same pond, which was approximately 1 square acre in area, also were killed, while none of the bivalves appeared to be affected.

Victoria Blue B, a biological stain, is another chemical compound, a solution of which will kill many undesirable forms, including common mussels, annelids, tunicates, certain gastropods, and hydroids. This chemical has been used routinely in our laboratory for over 5 years to check unwanted animal populations in hatchery troughs. The usual practice is to discontinue the flow of sea water through troughs and to create concentrations ranging from 1.0 to 2.5 ppm of the stain. As mentioned above, tunicates, annelids, mussels, and certain other competing bivalves, chiefly those that cannot keep their shells tightly closed, will be killed if subjected to this concentration for several hours. Hard shell clams, however, keep their shells closed and, consequently, remain unaffected. Some oysters, on the other hand, may open their shells during long immersion and receive a lethal dosage of the chemical. The Victoria Blue method, therefore, should be used with considerable care.

Still another modification of using chemical solutions is the so-called dip method. It consists of immersing a dredgeful of oysters, together with other bottom material, into a vat of the solution to destroy all predators and competitors that may be present (Figure 2). This measure prevents transplanting of undesirable forms from one bed to another by killing *Polydora,* boring sponges and other organisms that live within the shells of live oysters. Korringa (1951), using a solution of di-nitro-ortho-cresol at a concentration of 500 ppm, killed the majority of *Polydora* in shells of European oysters in this way within 3 hours. MacKenzie and Shearer (in press) repeated these experiments killing up to 90 per cent of the worms by exposing them from 1 to 3 hours to the above concentrations. However, when these workers used Victoria Blue B at a concentration of 200 ppm, they killed 97 per cent of the worms within only 15 minutes. MacKenzie and Shearer mentioned many other compounds that they found effective in the control of *Polydora* and other annelids inhabiting oyster shells.

The dipping of dredged oysters for different periods in Victoria Blue B and then leaving this material to dry in air also killed many undesirable forms, including tunicates and mussels. A detailed discussion of the use of Victoria Blue, as a practical method for killing oyster competitors, is offered in MacKenzie's article, which is now in press.

Copper sulfate is another compound that may be used advantageously to control oyster enemies and competitors by dipping them in a solution of this chemical. In the past we used this compound at Milford to kill drill embryos (Engle, 1941). Walne (1956) used different concentrations of copper sulfate to destroy fouling organisms on artificial oyster spat collectors. Glude (1957) showed that copper ions will effectively repel adult drills. Still more recently, MacKenzie (in press), in cooperation with local oyster companies, conducted

FIGURE 2. Experiments to develop dipping method to kill oyster enemies and competitors. Saturated solutions of common salt and weak dilutions of copper sulfate and Victoria Blue B are satisfactorily used for this purpose.

an extensive series of experiments in which copper sulfate was used to kill various oyster competitors. To kill mussels, MacKenzie recommends dipping them into copper sulfate solutions varying in strength from 0.5 to 1.0 per cent, if material is to be kept out of water for 24 hours or longer after dipping, and 1.0 to 2.0 per cent solutions, if it will be stored in air for only a few hours. This treatment kills mussels but does not affect medium and large oysters. However, young oysters, measuring less than 20 mm in length, should not be subjected to it even if the solution contains only 0.5 per cent of copper sulfate.

Another extremely simple but effective and versatile method to kill undesirable forms is the use of saturated or nearly saturated solutions of common salt (Loosanoff, 1958). By dipping the dredged material in a strong salt solution and then allowing it to dry on deck for some time, a wide variety of undesirable organisms can be destroyed. The method is extremely effective in killing shell-boring sponges of the genus *Cliona*. Complete mortality is achieved by immersing them in a saturated solution of common salt for only 30 seconds and then leaving them in air for at least 1 hour. Starfish, two species of *Crepidula*, several species of tunicates, the flatworm, *Stylochus ellipticus*, and many other undesirable organisms, including protozoa, hydroids, bryozoa, algae, and even small crustaceans, are killed by this method.

These experiments also indicated that a saturated salt solution may be helpful in controlling a drill population by killing their eggs and embryos while they are still in egg cases (Loosanoff, 1958). Heavy mortality of drill embryos was observed even when egg cases were immersed for only 3 minutes and then kept in air for several hours before being returned to sea water. Further studies on applications of strong and saturated salt solutions were recently completed at our laboratory, indicating wide application of this method (Shearer and MacKenzie, in press). We think that the dreaded shell disease of European oysters can be kept in check by wide usage of this method.

There remains one more approach to using chemical solutions in control of oyster enemies. It is thought that certain dangerous internal parasites of oysters and European mussels, such as copepods of the genus *Mytilicola,* may be eliminated by placing infested mollusks into solutions of certain insecticides (Loosanoff, Hanks and Ganaros, 1956). The method can probably be made more effective by adding to the solutions a thick algal culture which, after absorbing some insecticide, will be ingested by mollusks and later passed through the digestive tract, certain sections of which harbor parasitic copepods.

Chemical Treatment of Shellfish Bottoms

During recent years it was found that many enemies of bivalves can be controlled by the use of chlorinated oils, such as orthodichlorobenzene (Loosanoff, MacKenzie and Shearer, 1960a; Loosanoff, MacKenzie and Shearer, 1960b). Further experiments indicated that the effectiveness of the treatment can be increased by incorporating in heavy oils other chemicals, such as Sevin, an

FIGURE 3. Chemically-treated sand being washed overboard with strong stream of water to destroy enemies on oyster beds.

insecticide which is relatively non-toxic to mammals. The oils are usually mixed with dry sand, broken oyster shells, or other inert materials to "anchor" them on the bottom undergoing treatment.

By spreading chemically-treated sand over shellfish beds, several enemies, including oyster drills, can be either almost entirely eliminated or their numbers greatly reduced. The formula that usually gives good results consists of mixing, by volume, 95 per cent of dry sand with 5 per cent of chlorinated benzenes containing from 1 to 3 per cent of Sevin. The sand is spread over the area either by a machine, such as is used when spreading sand on icy highways in winter, or by washing it overboard by means of a powerful stream of water (Figure 3). Several experiments of this nature conducted during the summer of 1960 in Long Island Sound and Great South Bay were quite successful. They will be described in detail later on in other publications.

This method of covering large bottom areas with chemically-treated sand may also be used to kill starfish already on the beds. Particles of sand falling on the upper surface of starfish will imbed in the delicate membrane covering these pests, quickly disintegrate it and eventually cause death.

The same method is also effective in stopping the re-invasion of shellfish beds with a new generation of those enemies that have swimming larval stages, such as starfish, crabs, and flatworms. Ready-to-metamorphose larvae will die soon after they settle on, or move over, the chemically-treated bottom.

Still another reason for spreading chemically-treated sand over oyster growing bottoms is to eliminate the mud shrimp, *Upogebia,* the ghost shrimp, *Callianassa,* and related forms which, by their continued digging activities,

FIGURE 4. Oyster drills, *Urosalpinx cinerea,* swollen after contacting sand mixed with orthodichlorobenzene and Sevin.

render large bottom areas unsuitable for oyster culture (Loosanoff, MacKenzie and Shearer, 1960a). Preliminary experiments conducted on shrimp-infested bottoms of the State of Washington by Cedric Lindsay of the Department of Fisheries have indicated that these methods can be successfully used for this purpose (personal communication).

Chemical Barriers

Chemical barriers are made of a mixture of sand, such oils as orthodichlorobenzene, and other chemicals, depending upon what enemy or groups of enemies are to be controlled. We found that virtually all gastropods can be stopped by a barrier composed of only sand and heavy oils (Figure 4). However, as already mentioned, the efficiency of barriers can be increased by incorporating in them certain other compounds (Loosanoff, MacKenzie and Shearer, 1960a).

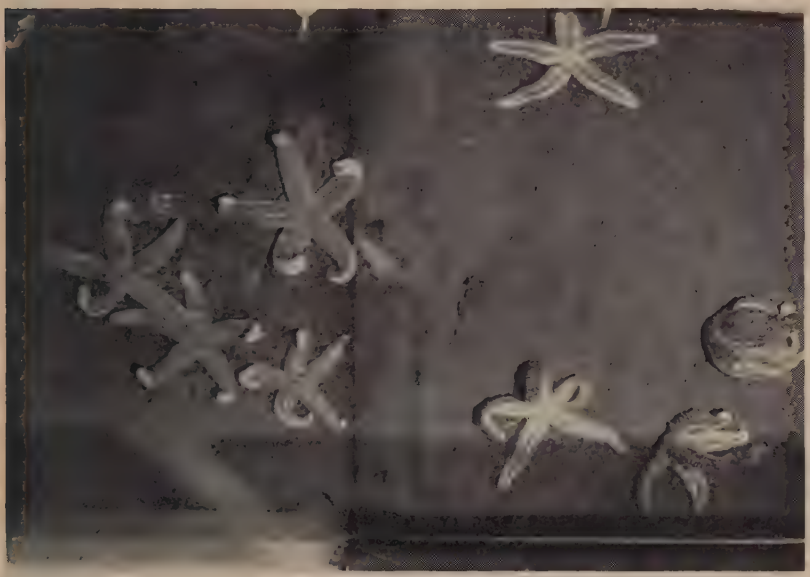

FIGURE 5. Starfish severely affected by chemical after contact with experimental barrier.

Several formulas have already been developed to arrest, under experimental conditions, movements of starfish, *Asterias forbesi* (Figure 5). Other formulas have been developed which seem to be effective in stopping, simultaneously, the movements of boring gastropods, starfish, and crabs. A promising combination for this purpose is orthodichlorobenzene containing small quantities of 2-chloro-1-nitro-propane and Sevin. However, since we do not know much about the toxicology of 2-chloro-1-nitro-propane and this material is expensive and difficult to obtain, another chemical, Rosin Amine D, manufactured by Hercules Company appears to be a good substitute. It will be tried next year on a large scale in Long Island Sound.

Because of recently acquired knowledge and quite extensive field experience, we can now create barriers wide enough and strong enough to stop movements of crabs. It should be remembered, however, that while this method may be safely applied in areas where crabs are of no commercial value, for example, in some waters of New England where the green crab is the chief enemy of the soft clam, in other areas, such as Chesapeake Bay, where the blue crab is an important commercial species, extreme care should be exercised. We hope, nevertheless, that by learning more about the application and special uses of chemical methods, life histories of different organisms populating aquatic basins, and by finding specific poisons that will affect only certain species of a large genus or family, we will eventually succeed in preventing unnecessary losses among useful animals.

We have experimented with barriers laid in laboratory troughs, in the intertidal zone of Milford Harbor, and finally in 20 feet of water on the bottom of Long Island Sound. In all cases we found that the barriers were effective as long as they did not become covered with a heavy layer of silt. During these experiments many interesting and important observations were made. For example, setting of oysters within the areas protected by barriers was just as good as on untreated bottoms. Furthermore, no noticeable mortality occurred among any forms within the barriers and, finally, growth of clams and oysters within the protected zones was just as rapid as in the outside areas established as controls (Loosanoff, MacKenzie and Davis, 1960).

The chemicals composing the barriers retained their strength for a considerable period. For example, the mixture constituting the intertidal Milford Harbor barrier, which was laid on April 19, 1959, was still strong enough to cause swelling of gastropods when tested in October 1960. Our divers also observed that, regardless of several heavy storms and a hurricane, the barrier laid on the bottom of Long Island Sound in 1959 was intact after one year. These observations indicate that, because of their long-lasting effectiveness, the use of barriers may be practical.

Prevention of Fouling

One of several difficulties experienced by oyster growers in this country and abroad is the rapid fouling of cultch. This is especially true when, to collect a new set of oysters, cultch is suspended in water. For example, in Milford Harbor, oyster shells or artificial cultch will be converted into balls composed of numerous fouling organisms within two or three weeks after planting.

Efforts to combat fouling have been carried on at our laboratory for many years. We discovered, quite some time ago, that setting of barnacles on spat collectors can be prevented if they are treated with DDT (Loosanoff, 1947). Our British friends continued these studies using, in addition to DDT, other chemicals, including Lindane (Waugh *et al.*, 1956). Recently, our studies have been considerably expanded. Experiments conducted last summer, which consisted of dipping oyster shells in certain heavy oils and, later, planting them in Long Island Sound for periods of 2 to 3 months, gave encouraging results. Oyster spat were more numerous on shells treated with certain oils, particularly Polystream and Polychlor mother liquor, both of which contain large amounts of tetrachlorobenzene, than on control shells.

These experiments, which were duplicated in Milford Harbor, not only showed that oyster set was heavier on shells treated with Polystream, but also that these shells were virtually free of fouling organisms, including barnacles,

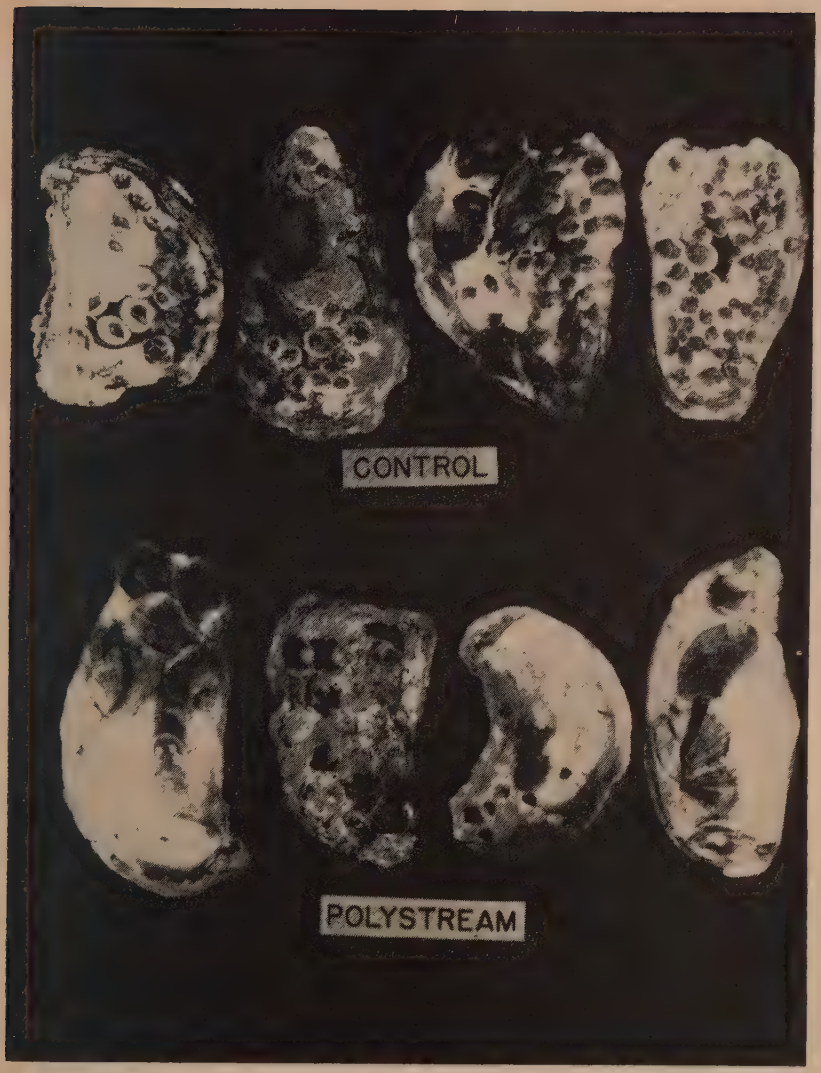

FIGURE 6. Photograph showing differences in intensity of setting of barnacles on Polystream-treated and control shells used as oyster set collectors.

tunicates, worms, hydroids, and the protozoan, *Folliculina* (Figure 6). What may be of special significance to the oyster industry of many areas is that shells treated with Polystream also repelled or killed the oyster leech, *Stylochus,* and its set. Extensive experiments to verify these conclusions are planned for next summer in the waters of several states.

Repelling Drills from Set Collectors

In some instances it may be practical to collect oyster set in areas where drills are abundant, provided that drills can be kept from attacking young oysters. This may be achieved by chemical treatment of cultch before it is placed in the water. Experiments of this nature were undertaken last year on oyster beds of Long Island Sound and Milford Harbor, and in outdoor troughs with running sea water (Loosanoff, MacKenzie and Davis, 1960). The oyster shells were dipped in one of the following: (1) orthodichlorobenzene; (2) orthodichlorobenzene and kerosene in equal volumes; (3) orthodichlorobenzene, trichlorobenzene and tetrachlorobenzene in equal volumes; and (4) a mixture of equal parts of orthodichlorobenzene, trichlorobenzene and tetrachlorobenzene, to which an equal volume of kerosene was later added. The final mixture was composed, therefore, of 50 per cent of the 3 chlorinated oils and 50 per cent of kerosene.

The results of the experiments were gratifying because they showed that oyster larvae set on oil-treated shells and, what may be even more important, that some of the mixtures, for example, that of 3 chlorinated oils diluted with an equal volume of kerosene, were effective for some time in keeping drills from attacking recently set oysters.

In the summer of 1960 the experiments were expanded by using a much larger number of collectors, new kinds of oils, and conducting observations in more locations. Since, at the time this report is being written, many collectors are still overboard and because the examination of samples is still in progress, we cannot offer final conclusions about the effectiveness of the method. However, we have sufficient evidence to conclude that all groups of shells dipped in chlorinated oils collected oyster set. Furthermore, in several cases oyster spat on oil-treated shells showed better growth than on control shells although, on the basis of present evidence, the rate of growth on oil-treated shells is, in general, somewhat slower. Finally, observations made during the past summer again indicated that drills are reluctant to attack oyster spat attached to shells treated with chlorinated oils. On the basis of the experiments carried on thus far, Polystream and Trimix seem to be the most effective agents to counteract drill activities.

A series of critical experiments to verify these conclusions is already underway. It appears, nevertheless, that the method will prove to be effective because, as soon as drills crawl upon Polystream or Trimix-treated shells, many of them swell and become unable to move. Probably touching the crystals of these oils, which can be seen on shells removed from the water even after being overboard for several months, affects the drills soon after their bodies come in contact with them. The method does not offer complete protection because some drilled oyster spat were found even on the treated shells. We hope, however, that by adding certain other chemicals to Polystream this will be prevented.

Baits

Use of chemically-treated baits to poison undesirable aquatic species, such as crabs, horseshoe crabs, rays and drumfishes, occurred to biologists some time ago. Our observations that crabs feeding on barnacles dipped in a solution of DDT went into convulsions soon after feeding, and similar observations by Dr. F. Gross of England (personal communication) led us to believe that poisoning of crustaceans can be simply accomplished by using insecticides. In our

screening of several thousand chemicals, which were tested on approximately 10 different species of oyster enemies, we found many that can be used either in bait or in solution to kill most crustaceans that have been exposed to these poisons. To determine the effectiveness of these substances on the group of marine arthropods that has presented or can present problems in shellfish conservation or in other aspects of mariculture, we used the following species:

Rock crab	*Cancer irroratus*
Blue crab	*Callinectes sapidus*
Lady crab	*Ovalipes ocellatus*
Mud crab	*Panopeus herbstii*
Green crab	*Carcinides maenas*
Hermit crab	*Pagurus pollicaris*
Spider crab	*Libinia emarginata*
Common sand shrimp	*Crangon vulgaris*
Mantis shrimp	*Squilla empusa*
Horseshoe crab	*Limulus polyphemus*
Copepods	(several species)

The results showed that all these forms can be quickly affected (Loosanoff, Hanks and Ganaros, 1956). A list of over 100 substances, which were found effective in our experiments against crabs, has recently been published (Loosanoff, 1960). We recommend Sevin, one of the insecticides that is least toxic to humans and fish, for incorporation in bait to kill crabs. Our colleagues at Boothbay Harbor, Maine, have made prolonged studies on the use of Lindane in control of green crabs and have recently reported results of their extensive and convincing experiments showing that control of these crabs can be easily accomplished by proper use of chemicals (Hanks, in press).

The use of poison bait distributed on the bottom, perhaps in the form of pellets composed of agar, clam meat and a poison and made heavy enough to sink by addition of sand, may also help us to solve a number of problems where crabs are intermediate hosts in transmission of diseases. For example, we are all familiar with the fact that the sporozoan, *Nematopsis,* quite commonly found in oysters, is transmitted by mud crabs. In the past, heavy mortalities of oyster populations have been ascribed to these gregarines. At present, another extremely serious mortality of epizootic nature is raging in the waters of several states along our Atlantic coast. The organism, which is suspected of being responsible for this mortality and which, at present, is called MSX, is also a sporozoan and, presumably, may pass the intermediate stage in the body of certain crustaceans, perhaps mud crabs or bottom shrimps. Because we now have several methods to exterminate crustaceans we may, in the near future, prevent spreading of several diseases by destroying intermediate hosts of parasites.

Other Uses of Chemicals

In many areas the oyster crab, *Pinnotheres ostreum,* is very common. This crab, living inside of oysters, usually causes considerable damage to their bodies and, in general, affects their quality, in some instances even causing death. These parasites, and they are true parasites, may be controlled or entirely eliminated by using various modifications of the chemical methods mentioned in this paper. A little experimentation along these lines will

probably point towards a simple but effective approach. We suggest that it consist of placing on an oyster bed, where such crabs are prevalent, certain organic solvents in which other chemicals, probably such insecticides as Sevin, are incorporated. These chemicals will dissolve at a comparatively slow rate and create an extremely light concentration of the insecticide near the bottom. This concentration, nevertheless, will be strong enough to kill the crabs in a few days. Perhaps our method of covering bottom areas with chemically-treated sand, which we recommend for control of drills, will be applicable. Next summer we intend to ascertain its effectiveness against *P. ostreum*.

I could continue with further suggestions about what can be done to control shellfish enemies not mentioned in this article, but it would be impractical because of the large number of cases to be considered. This article cannot be terminated, however, without mentioning that chemical methods may also be useful in control of shellfish diseases due to bacteria or fungi, such as the widespread fungus disease of southern oysters caused by *Dermocystidium*. This may again be accomplished by incorporating certain fungicides in the heavy oils and, after mixing the oils with dry sand, spreading the mixture over an oyster bed or surrounding the bed with a belt of this material. The slowly dissolving fungicides will gradually leave the oils and spread in a thin layer over the oyster bed, possibly creating concentrations, which will be sufficient to kill fungus already infesting the oysters or to prevent infestation of healthy oysters by fungus. Similar methods can probably be applied to control other microorganisms responsible for heavy oyster mortalities, including bacteria and, perhaps, even viruses.

In conclusion I want to emphasize that we fully realize that any chemical entering the water becomes a pollutant. Fortunately, the organic solvents that we employ in our formulas are virtually insoluble in water and, therefore, are relatively safe to use in an aquatic environment. Nevertheless, we are concerned with the potential danger of indiscriminate usage of large quantities of chemicals in aquatic controls. We also think that any compound to be used on shellfish beds on a large scale should be thoroughly evaluated by experienced biologists in terms of its danger to aquatic forms and, of course, in relation to human safety.

In other words, before the use of any chemical is generally recommended, a critical evaluation of the desirability of its usage should be made by comparing its positive and negative values. In our case, it will be especially important to determine the effects of chemicals on commercial species of shellfish, especially whether these compounds accumulate in the bodies of these mollusks rendering them undesirable or dangerous as food. Therefore, regardless of what components are recommended for the final formulas, their safety to humans will be fully established in accordance with recommended procedures.

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Economic Aspects of Markets for Middle Atlantic Oysters

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An historical analysis of oyster production and consumption in the United States shows that within the past 25 years two anomalous supply-demand situations have existed. Perhaps the most striking anomaly has occurred during the 15 postwar years when the domestic production of oysters, unlike the domestic production of most consumer goods, failed to respond to increased demand as a consequence of the sharp increase in population and per capita income. Preceding World War II, oyster production increased by about 34 per cent in the years from 1933 through 1937, at a time when general economic conditions were not conducive to such expansion. This expansion, however, was dissipated by a decrease in production which began in 1941. The fact now appears, that despite the brief 4-year expansion, oyster production nationally has remained fairly steady since 1933, without responding as would be expected to supply-demand imbalances.

The consumption of oysters in the United States is involved in the foregoing supply-demand situation. For many years the national per-capita consumption of oysters has been skidding downward. Although the unprecedented population and income growth of the postwar years created an expanding market, it did not halt the downward slide of per-capita consumption which began in 1937. Consumption was a little over three-fourths of a pound per person in 1937, and last year reached a low of 0.36 pounds per person. This figure does not include imported oysters. Imported oysters, largely canned, have had only nominal effect in bringing the per-capita consumption to 0.40 of a pound per person. The downward trend, particularly in the postwar years, appears to be a consequence of static production and rapid population growth. Some of the downward trend may be attributable to changing tastes.

Generally speaking, static production, rapid population growth together with an expanding national market, and increasing per-capita income have created a condition in the postwar years wherein the demand for oysters has exceeded the supply. The level of national consumption has been established and limited by the available supply of oysters on the market. This is particularly true in the case of fresh and frozen oysters to which the studies reported herein were directed.

It is self-evident, under supply-demand conditions which have existed, that the price of oysters would increase. An index of prices received for oysters by

producers, calculated by six producing areas in the United States, shows substantial increases following World War II. Price indexes in the South Atlantic and Gulf coast areas showed no increase. The view that prices respond to supply is further confirmed, in part at least, by a special statistical analysis of factors that influence price of oysters, and the characteristics of demand for Chesapeake Bay oysters conducted by Rutgers University for the Bureau of Commercial Fisheries. Supply is the most important factor determining price, according to the study. It was found that for every 1,000,000 pound increase in the quantity of oysters marketed the price will decrease by about 2 cents per pound. The next most important factor is the amount of disposable income that consumers have available. Disposable income is that income which is available to the consumer after taxes have been paid from his earnings. The United States per-capita disposable income increased about 1.75 times between 1946 and 1960.

In explaining the price in a particular area, another factor is the supply from near-by or competing areas. The effect of oyster supplies from the five state area consisting of Delaware, New Jersey, New York, Connecticut, and Massachusetts was analyzed in the Rutgers study. These five states also represent a principal market for Chesapeake Bay oysters. The two areas act as competitors, but because of the dominance of the supply from the Chesapeake Bay area little weight can be given to the competition from the five states as an influence on prices in the Chesapeake Bay area.

The Rutgers study analyzed and calculated the response of consumers, or, in other words, the character of demand for oysters as influenced by price and disposable income. The demand for oysters is highly elastic. This means that a small change in price results in a large change in the amount that can be sold. There is another type of demand which is called inelastic demand. It means that a change in price has only a small effect on the amount that can be sold—as with cigarettes. The effect of spendable income on both types of demand is the same as that of price. If the commodity has an inelastic demand with respect to price, the effect of spendable income is usually slight. If it has an elastic demand with respect to price, the income effect will be substantial. The fact that oysters have a highly elastic demand is not surprising, because they are not usually considered a staple in the diet. In most instances, non-staple items have an elastic demand.

The character of the demand is very important to producers of oysters. A small change in price or in spendable income brings about substantial changes in consumption of oysters. The significant fact is that with oysters, or any other product having an elastic demand, a lowering of price will bring about an increase in gross income up to a point. Hence, from the economic point of view, oyster production in the United States can be expanded from its current level, and in the face of possible reduction in prices the industry can expect gross income to increase.

The ratio of prices paid by producers for equipment and supplies to prices received for oysters by producers has been highly favorable to the Chesapeake Bay producers in the postwar years. The prices received index increased by 135.2 points from a level of 169.6 in 1946 to 304.8 in 1958, the last year for which it has been possible to make a calculation. On the other hand, the prices paid index increased only 66.4 points from a level of 117.5 in 1946 to 183.9 in 1958. The base year is 1942 with an index of 100.

The ratio of prices paid to prices received by producers, otherwise known as parity ratio, was 144.3 in 1946 and rose to 165.7 in 1958. In brief, this means that the economic conditions to make money in the oyster business were very good in 1946, and far better in 1958. Whether or not money *was* made depends also upon other things, the most important being the quantity and variability in size and condition of oysters put on the market.

Two oyster producing areas, the Gulf coast and the South Atlantic, have almost continuously experienced unfavorable price indexes since the War. One of these areas, the Gulf coast, has had prices of less than the base index of 100 in every year since the War except two. Elsewhere the price index has shown a substantial increase.

The parity ratio has generally shown a favorable increase in all areas but two; the South Atlantic and Gulf coast. It should be noted that production in these two areas consists predominantly of canned oysters. Prices of canned oysters tend to be more stable. In both areas the index of prices received for oysters failed to increase at the same rate as the index of prices paid, resulting in a downward trend in the parity ratio. The parity ratio for the Pacific Coast area turned downward in 1956, but since 1957 has remained at 100. Production of canned oysters is also relatively important in the Pacific coast area.

In the foregoing discussion it has been shown that:

(1) An imbalance has existed in the national supply-demand situation of oysters during the postwar years.

(2) Production of oysters has not met demand, hence per capita consumption has gone down.

(3) Generally the price of oysters has moved steadily upward.

(4) The supply of oysters has set the limit on national consumption.

(5) Favorable parity ratios demonstrate that generally the oyster business has experienced prosperous conditions.

(6) The demand for oysters being elastic, the market can absorb a greater production.

Despite highly favorable opportunities the domestic oyster industry has not closed the supply gap, so to speak. Numerous conditions have served to limit expansion. Foremost among these are the following:

(1) Loss of oyster producing areas.

(2) Damage by predators.

(3) Set-backs from time to time brought on by oyster diseases.

The area of productive oyster beds has been steadily decreasing as a consequence of encroachment brought on by the pressure of an expanding population. The shift in land use in the peripheral land-water environment is almost too frequently destructive for oyster growers. Such use probably explains the major loss of productive beds through siltation, construction, spoilment, and pollution by commercial and domestic sewage and industrial waste. An upper hand has not yet been obtained in the control of oyster predators and diseases.

There is a way for the American oyster producer to meet this market demand, and that is to test, modify, and implement methods which have been proven elsewhere. Included among these are the production of oysters on private or leased oyster grounds as contrasted with natural production on public grounds, and the use of raft and pond cultural methods.

It is a fact that foreign producers have designs to meet the long-standing shortages of the American market. Reports from Japan indicate that Japanese producers, and some Americans who have invested in Japanese oyster enterprises, are gearing for the American market. In at least one instance, a mass processing plant has been constructed to conform in operation to our standards of sanitation. A new technique for packaging and preserving frozen oysters for the American market has been developed. Once foreign oysters have entered the domestic market in quantity and obtained a competitive foothold, the domestic producer will be faced with another serious handicap.

Within the light of these circumstances, it is incumbent on oyster producers, utilizing findings from biological and technological reasearch, to immediately and aggressively undertake to improve production and marketing methods, and increase production to meet market demands and competition from imported oysters.

The Future of the United States Oyster Industry From a Biologist's Viewpoint

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OYSTERS ARE ONE OF OUR GREAT NATURAL RESOURCES and the oyster industry is one of the oldest in the United States. It is a variable industry, ranging from a wild fishery upon natural stocks of oysters to highly specialized farming carried out on private lands.

Many adversities face the oyster industry and cause speculation about the future of the resource and those individuals and companies engaged in it. The following discussion is an attempt to consider the biological aspects of the oyster industry; leaving to others the problems of processing, marketing, sociology, politics, and economics.

How can we predict the future of this sprawling industry which is spread over every coastal State, which uses many different methods, and has various local problems with little in common except the final product? Logically, we should examine the past to indicate trends. We should look closely at the present for today's problems are the best known, but with care lest we overemphasize their importance. Finally, we should look to the future in the light of our experience in the past, the present status and the hopes and problems which we can foresee.

The Past

Production trends on the Atlantic coast have been downward from peaks which were reached many years ago; yet in other places the reverse is true. For example, the Pacific oyster industry, which began less than 30 years ago, now has a stabilized production of over 10 million pounds of oyster meats per year. Production in the Gulf States has varied from year to year but this area continues to produce a substantial share of the nation's oysters.

The Present

These present problems of the oyster industry appear to be almost insurmountable:

1. *Decrease in Areas Suitable for Oyster Production.* Narragansett Bay, Rhode Island, for example, was once a major center of oyster culture in New England. At the present time it produces no oysters despite repeated attempts to gather seed and to grow seed transplanted from other locations. Although the exact causes are not known, it must be concluded that this area is no longer suitable for oyster production. Development of coastal and estuarine areas for industry, recreation or residential purposes has already destroyed many areas which were suitable for oyster production. This trend will certainly continue.
2. *Oyster Predators.* Hordes of starfish from the dominant 1957 year class have almost destroyed the oyster industry of Long Island Sound. Oyster drills in Long Island Sound and the saltier part of the Delaware Bay and coastal bays of Maryland and Virginia are a serious deterrent to economic oyster culture. Other species of oyster drills in the Gulf of Mexico and in the Northwest likewise cause serious losses of small oysters.
3. *Mass Mortalities of Oysters in Delaware Bay, Coastal Delaware, Maryland and Virginia and Chesapeake Bay.* Major losses have occurred since 1957. Although cooperative research is under way, the exact cause of these mortalities has not been determined.
4. *Oyster Mortalities Caused by the Fungus Dermocystidium.* In the Gulf of Mexico and in the warmer waters of the Atlantic coast this parasite kills a large percentage of the oysters each year.
5. *Shortage of Seed Oysters.* North of Virginia the industry is limited by a shortage of seed oysters since reproduction is less dependable than it is in the South Atlantic and Gulf States.
6. *Control of Mud Shrimps in the Northwest.* Recent increases in abundance of mud shrimps *Callionassa* and *Upogebia* have caused the destruction of many acres of valuable oyster land in Washington. These pests burrow through the bottom, making it too soft for oyster culture and increasing the deposition of the silt over the oysters.
7. *Unexplained Oyster Mortalities in Washington and British Columbia.* Approximately ten instances of oyster mortalities are reported to the Washington State Department of Fisheries each summer. Similar oyster mortalities also are reported from British Columbia. Causative agents or factors are unknown.
8. *Economic Problems.* While the cost of producing Pacific oysters has increased, the selling price is the same or lower than it was ten years ago. In other areas prices are favorable but supplies of oysters are limited.
9. *Importation of Foreign Oysters.* Canned and smoked oysters from Japan are being imported in increasing quantities. A new plant at Hiroshima, Japan, is producing frozen oysters especially packaged for shipment to the United States.

For each of the problems listed above, solutions can be found. The decrease in areas suitable for oyster production is part of the general "estuarine problem." The Gulf State Marine Fisheries Commission and the Atlantic States Marine Fisheries Commission have recognized the importance of this problem.

States and Federal agencies are expanding research to find ways of preserving essential coastal bays and estuaries and replacing those which are lost.

The control of predators appears much more promising than it did several years ago. Recent research has disclosed chemical and physical methods which after thorough testing should be available for commercial use.

Cooperative research by State and Federal scientists to determine the causes of mass mortalities in the Middle Atlantic area has increased greatly during the past two years. An organism suspected as the causative agent has been discovered but not yet identified. The 1958 and 1959 year classes of oysters in Delaware Bay have survived better than earlier groups which may indicate that a resistant strain is being developed.

The fungus parasite *Dermocystidium* cannot be controlled as yet; however, certain measures can be taken to alleviate its effects. Oysters can be marketed at a younger age or transplanted to areas where this fungus is less common.

Seed shortages can be overcome by utilizing certain areas where reproduction is dependable to produce seed for other areas. This is already being done in certain places but private collection of seed could be expanded. Artificial propagation of seed oysters is now possible and may provide economic sources of seed in the near future.

Recent advances in our knowledge of chemicals may make it possible to control the mud shrimp in the Northwest. Preliminary experiments show that these species are easy to kill but further testing is required before control methods can be advocated.

Although causes of the oyster mortalities in the Northwest are not known at this time, it appears likely that the problem can be solved with sufficient effort.

While other problems such as high costs, low prices, and imports cannot be solved by biological research, production costs might be decreased by better growing, harvesting or processing techniques.

The Future

If we can look far enough ahead we can see a bright future for the oyster industry after today's problems are solved. This will not be the oyster industry which we know at present for it will use new methods and techniques and new areas for oyster production. Consider the future in four phases without setting a timetable for each phase.

First Phase

Oyster culture in the United States could be vastly improved if the best commercial practices in use today and the present scientific knowledge were applied throughout the industry. Production could be increased, quality could be improved, and costs could be lowered. The need for food for an expanding population should maintain high consumer demand for oysters.

During this period antiquated laws which hamper private enterprise would be corrected. Experience in Long Island Sound, Chesapeake Bay, and the Pacific Northwest has demonstrated the tremendous increase in production which can be achieved through private cultivation of oysters as compared with public management. During this period nearly all oyster-growing areas would be placed under private control but some seed areas might still be managed as a public resource.

Most predator control problems should be solved during this period by measures which, though expensive, could be used economically by private oyster farmers.

Causes of mass mortality would be discovered during this period and some control measures would be developed. It is unlikely that this problem could be completely solved during this period.

The oyster industry will face several serious problems during this period. Foreign competition will undoubtedly increase. The quantity and quality of oystering areas will decrease and production costs will continue to rise. The oystermen will be challenged to produce a product more acceptable to the consumer, more attractively packaged, of higher quality but without an undue increase in price.

Second Phase

Industrial development and increase in population in coastal areas will cause a continued decline in the quantity and quality of suitable environments for oyster culture during this second phase. The runoff of fresh water will decrease and the load of silt, domestic and industrial wastes carried by the rivers will increase. These factors will make it necessary to relocate that part of the oyster industry which is close to centers of population.

New culture methods such as the use of rafts placed in deep water away from cities will more than replace the areas which are no longer suitable for oystering. Handling, shucking and processing techniques will be improved to reduce costs. Already the Japanese raft culture technique produces 600 to 1,000 gallons of oyster meat on a raft 24 feet by 60 feet in eight months. This principle improved by modern materials and American mechanization will make it possible to compete economically with foreign imports.

Improved techniques for purifying oysters will be in common use to guarantee highest quality to the consumer.

Third Phase

A further decrease in natural areas suitable for oyster culture will make it necessary to grow oysters in ponds. Research on pond culture of oysters is already under way and methods should be perfected by this time. Seed oysters would be produced in private, commercial hatcheries following techniques which have recently been developed and which will be improved before this period. Our knowledge of nutrition will be advanced to the point that producing food for oysters will be possible and economically practicable. Selective breeding will increase growth rates, reduce disease, and improve flavor and other characteristics. Predators will be excluded and most diseases will be controlled.

Fourth Phase

The ultimate in oyster culture would be artificial propagation not dependent upon naturally clean sea water or natural food. The oysters might be grown under completely controlled environmental conditions in a few months. It is already possible to produce a continuous supply of phytoplankton under closely controlled conditions, and this method might be used to produce the oyster's favorite food. Perhaps "oyster pellets" or "instant oyster food" will be commercially available. Even now larval clams can be raised on dried foods at the U. S. Bureau of Commercial Fisheries Laboratory at Milford, Connecticut.

The water used in oyster culture might be taken from the ocean, diluted

to the correct salinity and sterilized by ultraviolet light. Inland oyster farms might use artificial sea water which would be filtered, purified, and recirculated to maintain a perfect environment.

Oysters and other molluscs are among the most efficient sources of animal food since they feed directly upon plants. Their growth is rapid if food supplies are adequate and environmental conditions are satisfactory. Furthermore, the product is nutritious, well accepted and easily marketed. The prospects of increasing production of shellfish are extremely good; much better than the prospects of increasing quantities of other marine fishery products. Surely "Farming of the Sea" which we hold to be the solution to the food supply problem of the future will begin with culture of oysters and clams.

Predictions presented here are based on incomplete evidence and some unproven assumptions, but with faith in the ability of American scientists and the resourcefulness of American industry. Present problems can be solved and the future can be bright, but only if we obtain the knowledge which will be needed in the future.

Industry's Appraisal Of The Future of the Oyster Industry

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THOUGHTFUL LEADERS IN THE OYSTER INDUSTRY are seriously concerned with the future of their business. If our production continues to decline at the same rate as it has since 1954, less than 40,000,000 pounds will be made available to the consumer in 1970.

Some towns along the middle Atlantic Coast have become almost "ghost" towns already. More areas are feeling the pressure of a declining economy every day. The Eastern oyster, which was a staple part of the diet of our early settlers along the north and middle Atlantic Coast, is fast disappearing from the American scene.

Most of this discussion will be confined to the East coast from Maine to North Carolina, since in recent years this area has suffered the greatest losses of oysters and consequent decline in production.

Long Island, Delaware Bay and Chesapeake Bay have been recognized as the major oyster centers in the United States. Long Island was noted especially for its ability to grow excellent quality of oysters both for the half shell trade and the shucking industry, Delaware Bay produced excellent shucked oysters, but because of the vast acreage suitable for oysters, the Chesapeake yielded more than both of these plus all the other oyster areas in the United States.

The bulk of the oysters grown in these Eastern states, except Maryland, are cultivated on private grounds.

Since 1950 Long Island oystermen have sustained tremendous losses from hurricanes, starfish and drills, an unexplained mortality in 1953, and no commercial set until 1958. Delaware Bay growers in the same period have been

plagued with seed shortages, drills, and in 1957-60 almost complete destruction of all oysters by the new organism which has been discussed here by previous speakers.

In the Chesapeake Bay in Virginia production increased until 1959 as a result of increased farming in spite of great losses every year from *Dermocystidium* and drills. Since 1959 their catch has dropped drastically probably from the addition of "MSX" and this year from the damage of hurricane Donna as well.

In Maryland, a policy of planting shells on public beds, regardless of the time of spawning and setting, and regardless of whether the area planted obtained fairly regular sets, has resulted in depletion of most of the beds with a constantly declining yield. The only bright spot in this picture is the efforts of the present Commission in Maryland to plant the bulk of their cultch in high setting areas to grow seed and to foster and encourage oyster farming by private individuals.

Another factor, which should speed up Maryland's program of rehabilitation, is the utilization of dead reef shells as a sourch of cultch. The supply of such shells in Maryland waters appears to be vast indeed. If salinity actually proves to be a factor limiting the spread of "MSX," Maryland waters of lower salinity could well provide the "golden" future harvest for the middle Atlantic area.

In the last few years, certain East Coast oyster packers have sought sources of supply in the south, particularly in North Carolina, Alabama and Florida. A possible danger from this increased production pressure is that these public areas will be rapidly depleted too.

The south Atlantic and Gulf oystermen have benefitted from the misfortune of their East Coast friends by having an increased demand for their product. This excellent demand for Gulf oysters, coupled with abundant crops on the public grounds in Alabama, Mississippi, Louisiana and Texas, has enabled oystermen and packers in these states to have the best year in 1959-60 that they have enjoyed in the last fifteen to twenty five years.

It seems unlikely that this prosperity will continue indefinitely. Past history has shown that production from public bars in all of these states has been declining with intermittent upsurges while production has been increasing from private beds, particularly in Louisiana.

While our West Coast oyster industry is dependent on Japanese seed with the bulk of their seed supply from Japan, they have attained a relatively stable business and constant level of production. Even though plagued with industrial pollution in some of their major bays, beset with pests such as drills and ghost shrimp, and hampered by the lack of local seed, the Pacific growers have still been able to put most of the tidelands in the Pacific northwest into regular production and some growers are now using deep sea leases as well. However, the possibilities for expansion are limited by the bottoms available, at present prices of seed and selling prices of the product.

Aggressive merchandising and selling this season have already expanded the markets for Pacific oysters and at a higher price than ever before. In some ways the West Coast oystermen have the most promising future, so long as their source of seed remains stable and low priced Japanese imports of frozen oysters do not take over their markets.

The dismal prospects in the East have so discouraged some oyster growers and packers that they have liquidated their business. Others are debating

whether or not they should do the same thing before they dissipate their accumulated assets.

It is difficult for planters in parts of Long Island, in Delaware Bay and in the lower Chesapeake to be optimistic about the forseeable future. Unless the cause of the mortality in the latter areas can be determined immediately and methods developed for controlling it, the possibilities for profitable oyster culture are few indeed. Biologists estimate that from five to fifteen years probably will be needed to carry out all the studies necessary. Obviously, if the "MSX" killer continues the devastation at the present intensity, results at the end of five to fifteen years will be too late to benefit present oystermen. It is an enigma that the oyster, which has been studied more than any other marine species, would be the commercial species which would be ravished by a malady unfamiliar to the biologists.

What are the future alternatives facing the eastern grower? As mentioned before, he may go bankrupt and out of business anyway. A second possibility, if he can obtain sufficient financial resources, would be to embark on a program of oyster culture in ponds under completely controlled conditions and greatly improved methods of cultures. The obvious drawback to pond culture now is that adequate technical data are not available to insure the success of this type of enterprise on a commercial basis. Legislation to expedite the development of a research program to answer some of these questions in this approach failed to pass the last Congress, and there is no assurance it will obtain support in the coming Congress. Greater efficiency and improved techniques by growers is a possible approach which could be productive.

A third alternative, which would disregard existing growers, is the fullest possible utilization of the dwindling areas, where losses have not been sustained. The fourth approach is the immediate introduction of another species of oyster which might be resistant to presently known destructive parasites and which would thrive in the environment prevailing in the middle Atlantic area.

One such species would be *Ostrea gigas* which was introduced to the Pacific northwest and has acclimated itself there. Factors favoring planting this species are its rapid growth rate, high reproductive capacity, and ready availability of large quantities of seed. Another possibility is the planting of one or the other species of oysters native to European countries. The flat European oyster, *Ostrea edulis,* grown for several generations at the U. S. Fisheries Laboratory at Milford, has already been planted in the waters of Maine. From a planting of only one bushel, a bed of oysters has accumulated there. Furthermore, oysters of this species have been found fifty miles from the original experimental planting.

It cannot be emphasized too strongly the seriousness of the present situation. United States production has dropped to one half what it was fifty years ago. I repeat again, if the present trend continues, production will be 40,000,000 pounds or less by 1970. That is only one third of the catch just after the turn of the century. On the other hand, in the other major oyster producing country —Japan—oyster production has been increasing at a startling rate. In 1954 their yield was 28,800,000 pounds, in 1960—estimated 40,000,000 pounds and probably at least 50,000,000 pounds by 1970.

Our biologists and administrators are too complacent about their own little niches of interest. We have to have some fresh, forward thinking if we are to save our third most valuable fishery. Research along old traditional lines is

great and much scientific knowledge has been accumulated for posterity and for our scientists in the future. But, I think our biologists and administrators must be realists. We have a dying industry, which cannot wait ten to fifteen years. We need new ideas and action now! If you will, we need courageous leadership willing to strike out before all the facts are in, to try, yes, even to fail; but in failing to point the way for progress and success.

Possibly all of us are guilty sometime of seeking our own personal security first. It is perfectly natural to be cautious before acting. But, security is a nebulous thing and sometimes can be attained only by striking out from the old paths.

Today, large quantities of oysters are being canned in Japan and sold in American markets. Others are being frozen for export to the United States. Plans are developing for other Japanese firms to do the same thing. With present United States scarcity and high prices there can be little objection to these imports if they are grown and packed under sanitary conditions comparable to our own. This is only another reason why we must move swiftly, if our industry is to survive. While the East Coast industry struggles to survive Gulf and Pacific oyster growers can anticipate a period of prosperity for the immediate future, if they can only maintain production at the same rate. I predict that within the next five years a substantial number of packers in the East will, from necessity, be selling frozen oysters from Japan, and another group trying to grow some foreign species in their waters.

Only those who are adjusted or who can adjust to their environment survive in nature. Approximately the same laws seem to prevail in an economic struggle for survival. Many oystermen, shuckers, packers, boatmen, etc. have already lost out. Of those remaining, only the people who are able to modify their operations to the new circumstances can be expected to survive the natural catastrophies which have befallen them. And our oystermen, biologists and administrators, who are unable to take a forward view, will lose out to the flooding tide of disaster. I appeal to those here, who are considered leaders in science and industry, to drop complacency, forget personal differences, if they exist, and unite in the restoration and development of a sick fishery.

TRENDS IN OYSTER PRODUCTION IN U. S. AND JAPAN

Year	JAPAN Pounds	U. S. Pounds
1954	29,823,750	81,922,000
1955	31,873,725	77,515,000
1956	36,962,250	75,134,000
1957	41,027,250	71,658,000
1958	44,312,710	66,396,000
1959	46,000,000[1]	63,000,000[2]
1960	48,000,000[1]	59,000,000[2]

[1]Preliminary Estimate—Japanese Ministry of Agriculture and Forestry
[2]Our estimates

FRIDAY—NOVEMBER 18

Chairman—DANIEL H. JANZEN, *Director, Bureau of Sport Fisheries and Wildlife, Washington, D.C.*

How Can Research Production Be Measured?[1]

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THOSE RESPONSIBLE FOR THE ADMINISTRATION of research programs find it very difficult to judge whether progress is satisfactory. How can we measure this progress? We must first decide what kind of information should be produced and how this information should be communicated to other research workers, to action levels of administration, to any affected industry, and to the general public.

In answering the question concerning the type of information required, a sharp distinction must be drawn between management and research. A biologist may gather routine data to give management continuous information needed to insure intelligent use of a resource. This is not research. Should these data also prove adequate on analysis to throw new light on some aspect of biology, it would be fair to charge some portion of the cost of collection to research. In many cases, however, an experiment can be designed to bring out the biological facts at less cost, and in more clear-cut fashion, than by using data collected for other purposes. This was well exemplified in Alaska for years before statehood. The problems of management were so great and so pressing that the federal research biologist had to spread his field activities over wide areas and gather data to answer specific questions needed for management in particular localities.

If such a situation were recognized and sufficient funds and personnel made available, perhaps this handicap could be overcome. In the case cited, however, the inevitable siphoning of already inadequate research funds into quasi-research activities delayed the acquisition of basic biological information. In the long run, management suffered from failure to discover some of the underlying biological principles sorely needed for wise management.

Let us then define research as the search for new knowledge. And let us not quibble about basic and applied research. The idea of research for the sake of research and anxiety to avoid the stigma of identification with any organism or process beneficial to man is not a useful concept. There is no dividing line between "basic" and "applied" research. Biological principles may be elucidated through the study of any species whether or not it is currently useful to man.

The second question—communication—has plagued scientists for years.

[1]Contribution No. 133 of the Galveston Biological Laboratory, U.S. Bureau of Commercial Fisheries.

There is often a long gap between the completion of a piece of research and the appearance and dissemination of a technical report. In fact, this is one of the main arguments favoring annual reports of research groups chronicling the progress and stage of completion of each research project.

Following a technical report on a research project there often arises need for translation of the report into a summarized and simplified account of the facts or principles studied, with some evaluation of their significance. Research personnel are therefore expected also to turn out material of a popular or semi-popular nature, as well as minor reports on techniques, methods, research outlines, translations, abstracts, informational leaflets, raw data reports, and so forth. Although none of these latter reports can take the place of the technical report, they are of undoubted value, and the authors deserve credit.

This leads us to the crux of the problem. Simply stated it is, "How do we determine whether progress is satisfactory?" Research progress cannot be measured in terms of dollars spent, laboratories built, or file cases stuffed with observations. Essentially a mental discipline, it cannot be sequestered or evaluated until transposed to paper. Only by evaluation of the written report, the final product, can we judge whether progress is satisfactory. Furthermore, in practically all cases in which research projects have for any reason been abandoned before a final report was written, a waste of funds has resulted. The published report then, of necessity, will be used as our yardstick of progress.

The problem now resolves into the determination of two things: (1) How much effort went into the production of a report, and (2) What is the relative worth of any individual report.

Money alone is a poor yardstick of effort. It often costs more to perform a stated amount of research in one locality or discipline than in another. Whether to continue the more expensive operation usually remains a policy decision. However, in judging performance at any two locations it would be patently unfair to judge effort by the amount of funds. This becomes especially noticeable when comparing costs of inshore research with mid-ocean research entailing large vessels and crews.

Facilities in terms of offices, laboratories, and vessels are not readily comparable. The nature of the problem largely determines the cost of the necessary facilities. A biochemist requires a well-equipped chemistry laboratory, a field biologist may occupy a small office, but require a car, a small vessel, perhaps field aids. In each case the researcher is provided with the means, whether cheap or expensive, to perform experiments or gather field data in order to solve a particular problem. In judging research production then, we must assume that each researcher has been provided with facilities in accordance with his needs. When production is below standard, facilities should be scrutinized, since research facilities are rarely fully adequate.

Since we have eliminated both funds and facilities, there remains the research man himself as our unit of effort. Because research is primarily a mental process, the bottleneck to production at many laboratories is the small number of scientists with the ability to analyze raw data, devise adequate tests of hypotheses, make logical deductions, and then convert these conclusions into intelligible reports.

Use of the scientist himself as the unit of research effort entails the question of whether or not we should recognize categories of effort, say between junior

and senior scientists. The use of categories is difficult for many reasons: different research groups have a different number of categories, and promotion and salary rates vary so that it would be difficult to establish comparable ratings. Moreover, ratings do not necessarily reflect either ability or experience. Although productivity usually increases with time, it often reaches a peak; thereafter it may tend to decline as the researcher—now an incipient administrator—is given more and more outside duties. Moreover, the length of time spent in each grade will vary with availability of funds. Examination of publication records indicates that it normally takes about 4 to 5 years for a man to reach a high rate of productivity.

Having decided on the scientist as the unit of research effort we come to the difficult task of deciding on the method of evaluating publications produced by the researchers. Because of the difficulty of evaluation, there has long been a tendency to rate scientists on the number of published articles. However, the mere enumeration of titles is almost worthless in assessing production. Some titles represent but a few hours of work; others are the culmination of several years of dedicated endeavor. To place them on the same footing is to make a mockery of science and discourage honest diligence.

Thus it is understandably discouraging to the dedicated research worker to read an announcement that so and so, who has just been hired, promoted, or given some honorary post, has published 50 or 60, or perhaps 80, scientific articles. After racking his brain the poor worker can remember perhaps three or four articles. Where did the rest come from? If we allow for some overpublicity, we may find the list was actually only 45 articles. Ten were semipopular articles in trade journals, another 10 were short notes on species distribution, perhaps 8 were general science notes in the journal of a local academy of science, 4 or 5 were published as abstracts (meaning an article on the subject may be forthcoming someday, if and when), several were processed (often merely a polite term for mimeographed) reports that never got far beyond the local office, the remaining 8 or 9 articles may have included 2 or 3 really worthwhile scientific contributions. This is not an attempt to indict the voluminous writer, but merely an example of how the use of false values in measuring research production may sometimes lead to erroneous conclusions.

In evolving an objective method for rating publications of research personnel, it should be emphasized that the primary function of research is to produce new knowledge. As a consequence, stress is placed on those articles which lay the foundations for new facts or principles. If a research worker can obtain sufficient publication credit by putting out progress reports and semipopular filler, he may never be persuaded of the necessity for concentrating on the kernel of his subject.

There will always be some criticism of any method of rating publications because their valuation is somewhat dependent on the point of view of the appraiser. Ratings must also bear some relation to the effort required to produce them. By effort, we do not mean physical labor; we reiterate that research is a mental process. After some study, I have evolved a system that attempts to encourage the writing of good technical reports, at the same time giving credit for all types of articles related to research.

The reports have been grouped into six categories based largely on content as follows:

Category A:

Original research requiring extensive analysis or original thought published in a scientific journal, or as a textbook or reference of college level. May include articles describing original techniques and apparatus.

Category B:

Research employing known techniques such as stream surveys, censuses, routine sampling when analysis is not extensive. Includes doctoral dissertations, revisions of textbooks or references, and taxonomic descriptions, keys, or reviews.

Category C:

Narrative and informational reports of scientific merit not requiring analysis. Includes general books or chapters on conservation, encyclopaedia articles, and technically correct information bulletins.

Category D:

Reports designed to make raw data available which may include short descriptions of methods and procedures but no analysis. Includes bibliographies, faunal lists, and glossaries.

Category E:

Semi-popular and popular articles, short descriptions of research programs, summaries of research accomplishments.

Category F:

Short faunal notes on species range, etc., critical book reviews, articles published only as abstracts, technical research notes in annual laboratory or commission reports, semipopular articles published in newsprint journals (not in newspapers).

The division of page credit between authors for multiple-author reports is shown in Table 1.

TABLE 1

PER CENT OF PAGES CREDITED TO EACH AUTHOR TO THE NEAREST ONE-HALF PAGE[1]

Number of authors	Position of author's name				
	1	2	3	4	5
1	100				
2	60	40			
3	50	30	20		
4	40	30	20	10	
5	40	30	20	10	0

[1]In case of a tie the extra one-half page belongs to the more senior author.

To obtain adequate material for a study of research production we have analyzed the publications of 60 scientists of the Fish and Wildlife Service during the 17-year period from 1940 to 1956, inclusive. No one was included with less than 10 years of work during the period; 32 worked for the entire 17 years.

First we determined the relative number and length of publications by type (Figure 1 and Table 2). This shows that out of 896 articles (solely or partially authored by one of our sample) 64 per cent were published outside of the Service. However, the articles published outside averaged but 12 pages in

TABLE 2

ACTUAL PAGE LENGTH OF ARTICLES BEARING NAMES OF THE 60 SCIENTISTS SAMPLED

Pages	Category A			B			C			D			E			F			Total		
	FW	O	T[1]	FW	O	T	FW	O	T	FW	O	T	FW	O	T	FW	O	T	FW	O	T
1-5	20	33	53	27	9	36	34	15	49	2	1	3	5	114	119	7	116	123	95	288	383
6-10	15	59	74	21	22	43	23	10	33					27	27		3	3	59	121	180
11-15	5	28	33	5	12	17	5	6	11	2	1	3		2	2				17	49	66
16-20	13	18	31	7	8	15	7	1	8	3	1	4		4	4				30	32	62
21-30	16	16	32	8	13	21	9	3	12	6	1	7		1	1				39	34	73
31-40	6	6	12	4	12	16	3		3	2	3	5					1	1	15	22	37
41-50	3	2	5	5	4	9	2	1	3	1		1							11	7	18
51-60	7	1	8	1	3	4				3		3							11	4	15
61-70	3		3	3	2	5	1		1	1		1							8	2	10
71-80		4	4	4	1	5				5		5							9	5	14
81-90	3		3	1		1													4	0	4
91-100				2		2				1	1	2							3	1	4
101-110	1		1	4		4	1	1	2	7		7							13	1	14
> 110	3	2	5	1	3	4	1	1	2	5		5							10	6	16
Number	95	169	264	93	89	182	86	38	124	38	8	46	5	148	153	7	120	127	324	572	896
Per cent	36	64		51	49		69	31		83	17		3	97		6	94		36	64	
Ave. No. Pages	27	15		25	24		14	16		63	32		3	5		3	3		26	12	17

[1]FW — Fish and Wildlife; O — Other; T — Total

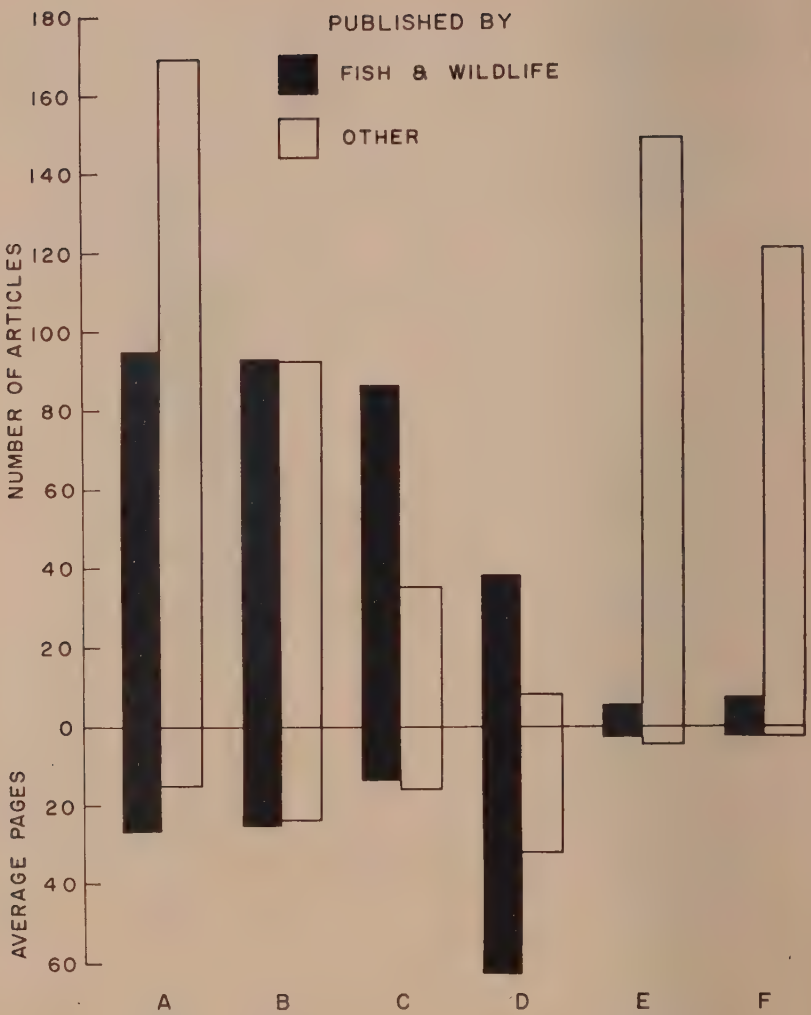

FIGURE 1. Number and length of articles by categories bearing the name of one of the selected group of 60, 1940-56.

length compared to 26 pages for Service publications, so that the Service actually published 56 per cent of the pages. Of the articles requiring most research analysis (A Category) the Service published only 36 per cent of the articles, but 50 per cent of the pages.

The great number of very short articles in the E and F categories (which do not require extensive research) demonstrates that number of articles published would be a very unreliable index of research production.

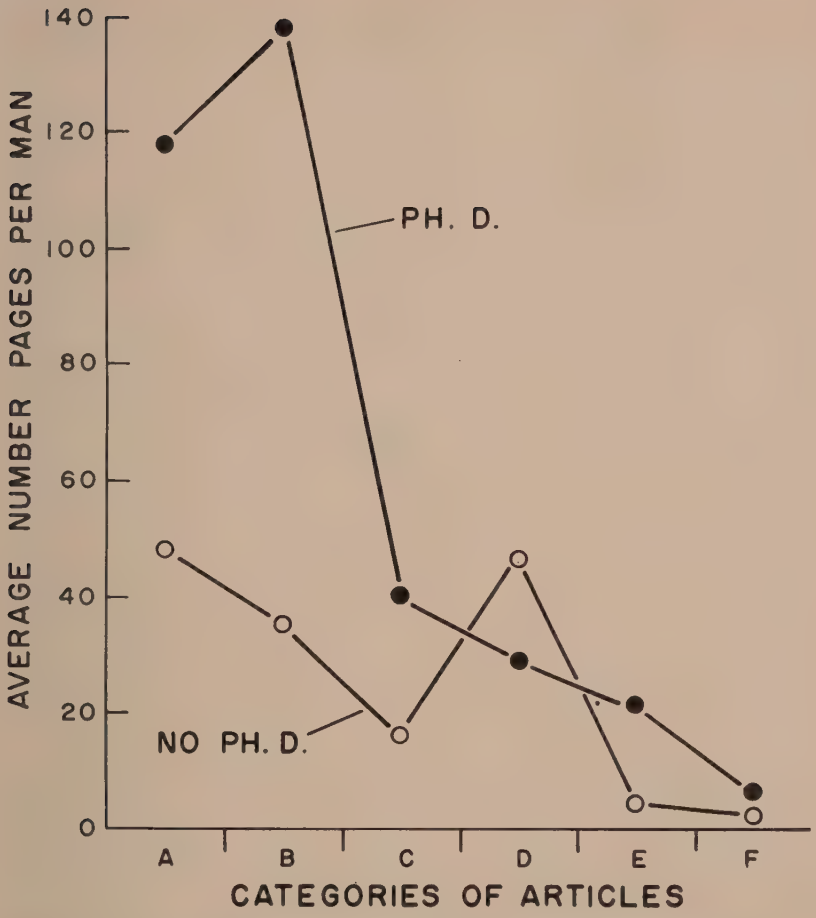

FIGURE 2. The average number of pages according to category, published per man on a 17-year basis by scientists with and without the doctorate.

That the number of pages published is also not too reliable an index is shown by the great length of the articles in Category D, which are chiefly raw data. It should be observed that only 16 of our sample of 60 published an article in this category. This is the only category in which those with Ph.D.'s published less pages per man than those without (Figure 2).

Obviously neither number of articles, nor number of pages can serve as an index. The number of pages published would be fairly reliable if it were not for the great variation between categories in the value of the product. The only practical solution is to use the number of pages weighted by categories according to their relative contribution to research.

TABLE 3

ADJUSTED PAGE CREDITS OF 60 SCIENTISTS BY ACADEMIC TRAINING AND FIELD OF WORK

Adjusted page credits	Without doctorate degree				With doctorate degree				Total	
	Anadromous	Inland	Marine	Other	Anadromous	Inland	Marine	Other	Without doctorate	With doctorate
0-200	6	1	1	1					9	
201-400	4	1	2						7	
401-600	5				1				5	1
601-800	1	2	2	1			1	1	6	2
801-1000			2	1		1	1		3	2
1001-1500		1	2			3	2		3	5
1501-2000			2			1	1	1	2	3
2001-2500		1	1		1	1			2	2
2501-3000			1	1			1		2	1
3001-4000						1	1			2
4001-5000						1	1			2
5001-6000										
6001-7000								1		1
	16	6	13	4	2	8	8	3	39	21

The relative weights of each category employed in my analysis are:

A - 10
B - 5
C - 3
D - 0.5
E & F - 2

The compilation and listing of raw data, the tedious and meticulous listing of bibliographic references, or the listing of species distributions require care and exactitude but not deep scientific thought. It must also be remembered that practically every good research paper sprang from a large quantity of raw data that had to be meticulously listed and tabulated prior to the actual analysis for the research paper. Because some of these original data are made available (almost universally now by photo reproduction) in multilith form, hardly entitles the author of a 25-page research paper to claim much credit for releasing 250 pages of listed data. On a basis of 10 credits per page for Category A material the per-page credit for Category D has been set at 0.5.

Categories E and F differ somewhat in content but agree in their brevity; 86 per cent of 280 articles were under 6 pages and only 3 per cent were over 10 pages. These have been given 2 credits per page.

The ratings of the 60 scientists according to academic training and field of work (Table 3 and Figure 3) show clearly that those with the doctorate averaged considerably higher than those without. Thus 69 per cent of those without, rated less than 800 credits compared to only 14 per cent of those with the doctorate.

It is noteworthy that the anadromous non-doctorates rated very low. This is perhaps partially explained by their over preoccupation with the gathering of field data because of the pressure of management problems in Alaska and on the Columbia River. Data alone cannot answer questions. It must first be subjected to careful analysis.

Perhaps the chief difference between the production of the different groups lies in the approach. The first work on a new problem is usually exploratory in nature. Some investigators can never carry their problem past this stage because they are unable to form hypotheses concerning the problem. Or, if they form hypotheses, they attempt to prove their validity or invalidity with haphazardly collected data rather than through systematic observations predesigned for use in testing their hypotheses.

This difference of over two orders of magnitude in individual production is truly astonishing. How did it come about? What causes it to continue? And, what is the remedy?

The production of research results depends on at least five factors:

1. Ability. Research requires a special kind of ability. Many intelligent people are miscast in a research role because either they lack intellectual curiosity, or they are unable to do the concentrated disciplined thinking required.

2. Training. Research requires good training. We cannot afford to start every problem with crude experiments and repeat every mistake of the past. Research requires a special type of training. Too many colleges are teaching men how to collect material and analyze it by already standardized techniques

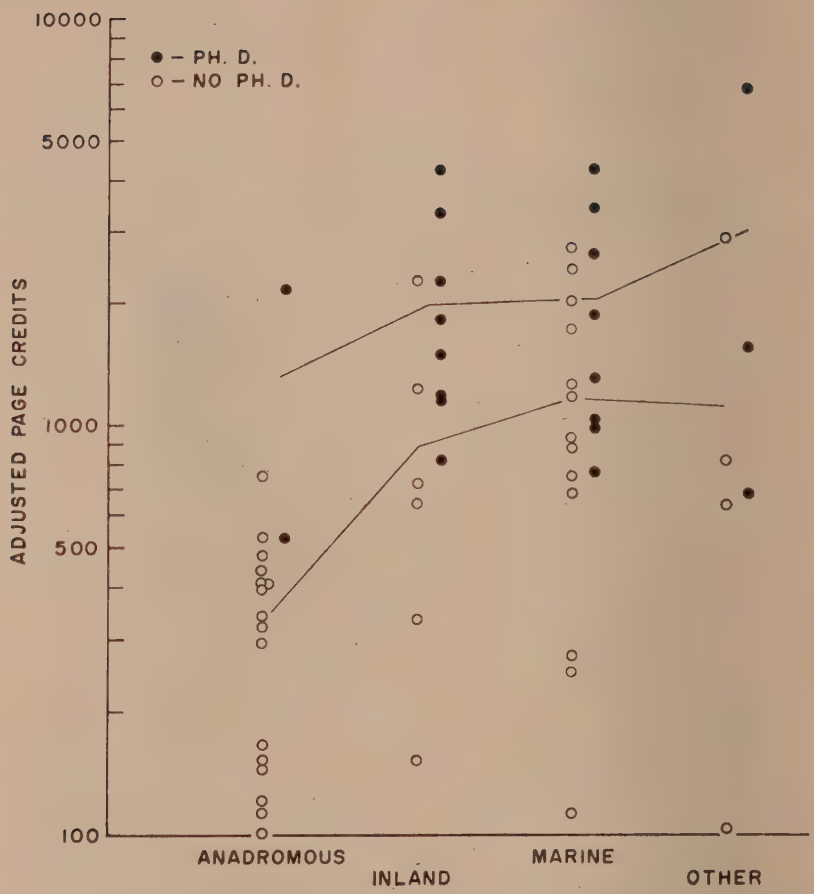

FIGURE 3. Page credits adjusted by categories, shown according to training and field of work, for the 17-year period.

without teaching how one goes about the intellectual probing necessary to solve a new problem. The result is the turning out of numbers of skilled workmen or technicians if you please. They are helpful up to a point, but many never achieve the ability to solve problems.

3. RESEARCH CLIMATE. This factor, often ignored, is of the greatest importance. Junior men of ability may wither or develop according to their scientific associations and the type of leadership furnished them. Junior men forced to work at lonely field stations often lose their interest at a time when stimulation is most needed.

4. PHYSICAL FACILITIES. Research is costly and requires the best of facilities. Carrying out a program of research without adequate physical facilities is not

economical. If facilities are inadequate for solution of a problem, it is wiser not to attempt it rather than to siphon off money always needed elsewhere. Striking examples of this lack are laboratories that are in reality only offices, with no provision for study of living material; research vessels that are cast-off hulls partially adapted for hydrographic research at great expense, yet not suitable for the job; and field stations so poorly devised for living that men spend precious time in merely managing to exist.

5. Adequate staffing. It is essential that there be some relation between the size and training of the available staff and the problems they are expected to solve. If the staff is too small or lacks certain specialization, an effort should be made to reduce the immediate goals to those than can be met. An attempt to study at one time all ramifications of a large problem may be very frustrating. If a problem cannot be broken into small enough self-contained phases that can be tackled one at a time with reasonable assurance of progress, then the problem should be shelved until adequate staff is available.

We have noted the great range in apparent productivity of individual investigators and have discussed some of the factors involved. The obvious question posed is: Can some of these factors be changed so that production is increased? We believe they can.

Concerning the first factor, ability, we submit that since research is largely a mental process, it requires much higher than average intelligence. Out of the many workers hired, only a few are of research calibre. Yet because of the compartmentalization of an organization, a man hired to do research is continued in research even though it finally becomes apparent that his services could be more advantageously employed in other phases of conservation work. Part of the difficulty arises from the fact that an insufficient proportion of those of higher intelligence are attracted into research. Part of the problem arises from the fact that it is extremely difficult to judge during his first year as an investigator whether a man will turn into a research worker. After the first year, at which time he obtains permanent status in our Service, the tendency is to continue advancing a man without due regard for his productive capacity. Indeed, since it is normal for junior scientists to collect and compile data and work under rather immediate supervision, it may take some time before it is realized that he lacks originality or perhaps the ability to transpose ideas into actual reports. A weeding-out process for selection of those who should continue in research should be made at intermediate levels. Those not adapted to research should then be transferred to other activities. Most of these people are sincere, hard-working employees who can contribute in many fields but lack that certain quality demanded by research.

Training is certainly an important factor in research. As shown in Figures 2 and 3, men with the doctorate averaged about twice as much in publication credit as those without. It will be noted, however, that in the marine field many without doctorates were close to the top. Many of these have had up to as much as two years of graduate training without taking a doctorate. There are thus indications that although good research men will perform well despite lack of graduate training, extra academic training confers a distinct advantage. Part of the reason for the higher average of those with doctorates may lie in the selection process of the universities themselves. Most universities of high standing accept only the better students as doctoral candidates, and many never

succeed in attaining their degree. The Fish and Wildlife Service has recognized this need for advanced training in the program just adopted for permitting selected employees to attend universities for graduate work at Service expense.

RESEARCH CLIMATE is not easily defined but is a rather essential ingredient. A man of intellectual curiosity, given a challenging problem, adequate equipment and library facilities, and association with other research workers, will usually produce to the limit of his ability and training. The kindling and maintenance of genuine interest are greatly augmented by his associations. This is why a large group of researchers, containing specialists in several related disciplines, normally can boast of a higher production per man.

PHYSICAL FACILITIES are costly to acquire and maintain, yet without certain facilities some problems can never be solved. Because of the cost, it is not possible to equip an unlimited number of laboratories with seagoing vessels, adequate libraries, chemical and bacteriological laboratories, large sea-water systems, and reference collections. There is often pressure by well-meaning people to build new laboratories in new locations. In only a few specialized cases are these justified. The Fish and Wildlife Service now has a number of strategically located laboratories, and these should be fully equipped before any more are seriously considered. Furthermore, the overhead cost is proportionately much less on larger installations.

ADEQUATE STAFFING means that each problem studied should be assigned the number and type of personnel required. This presents many difficulties since some problems require specialists in very circumscribed fields. Where a problem promises to be of long duration, or at larger laboratories where problems of the same type are likely to recur, the hiring of specialists in narrow fields is often justified. For short-term problems the Fish and Wildlife Service has more recently met this problem through contract research with institutions having specialists in the required fields.

In summary, the analysis of publication records of 60 Fish and Wildlife Service scientists over a 17-year period shows a tremendous range in research production. A portion of this difference can be ascribed to the higher production rate of those with advanced academic training, and the lowered production of those closely associated with specific management responsibilities.

Suggested measures to raise production include the transfer of intermediate grade research employees who are low in research production into other fields of activity within the Service. The new Fish and Wildlife Service policy of providing opportunity for advanced academic training of selected employees is heartily endorsed. The provision and maintenance of adequate facilities by concentrating personnel in existing laboratories is recommended.

Tagging of Anchovetas (Cetengraulis mysticetus) in the Gulf of Panama

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Inter-American Tropical Tuna Commission
Panama, R. P.

INTRODUCTION

IT IS THE RESPONSIBILITY of the Inter-American Tropical Tuna Commission to investigate not only the tropical tunas of the Eastern Pacific Ocean, but the species that are used for bait for tuna as well. One of the major bait species is the anchoveta, *Cetengraulis mysticetus,* and its most important source of supply is the Gulf of Panama. The anchoveta occurs in numerous shallow bays and estuaries from Mexico to Peru, and meristic studies of the major populations indicate that they are distinct (Berdegué, 1958).

It is desirable to tag anchovetas in order to verify the findings of the meristic studies, to determine the amount of intermixing of fish of different areas within the Gulf of Panama, and possibly eventually to estimate the size of the population and other important parameters. This paper summarizes these studies to the present time.

External Tags

Several short-term holding experiments with various types of external tags were conducted, and it was concluded that the Scottish toggle tag (Wood, Parrish, and McPherson, 1955) was the most suitable for anchovetas. In 1954, 1955, 1956, and 1957, 82,989 anchovetas were tagged in the Gulf of Panama, but only 16 recoveries were made (Schaefer, 1955 and 1958). Most of these had been at liberty only a short time, and complete recovery data were not available for some of them, so the results are of limited value. The low rate of recovery of these tags was attributed to one or more of the following factors: (1) a high tagging and handling mortality; (2) a high shedding rate; (3) a very low fishing intensity; (4) low visibility of the tagged fish in the live wells of the fishing vessels.

Holding Experiments

Live box experiments were conducted in 1955, 1956, and 1957 to test the retention of the tags and to obtain estimates of the mortalities caused by tagging. A series of unfortunate accidents terminated all the experiments prematurely; however they lasted sufficiently long to show that a considerable portion of the tags were shed within a short time after tagging. In 1958 and 1959 successful live box experiments were accomplished with a variety of external tags. It was shown that though the external tags did not cause appreciable mortalities to healthy fish, the tags were shed rapidly, very few of any type being retained more than one month (Schaefer, 1959 and 1960).

The intensity of the local purse seine fishery for anchovetas for reduction increased greatly in 1959. Since metal internal tags are recoverable by use of magnets in the reduction plants, their use became practicable for the first time. Internal tags were tested in the live boxes in 1959 and 1960, and it was found that they are much more suitable for anchovetas than external tags

(Schaefer, 1960). Shedding of the internal tags amounts to about 35 per cent, virtually all of which occurs during the first month after tagging. It is not known exactly what mortality the internal tags cause, for this varies with the condition of the fish and is probably different for fish held in captivity than for fish released into their natural environment. Fish which had been acclimated to the live boxes for about a week before tagging showed no more mortalities after tagging than control fish. The weakest fish that were tagged on the same day they were captured showed mortalities of well over 50 per cent within a few days after tagging, while control fish exhibited mortalities only slightly lower. Unfortunately there is no way to know how well these fish would have survived if they had been released into their natural environment instead of the live boxes.

In 1960 live box experiments were conducted to study such refinements of the internal tagging technique as the use of anesthetics to tranquilize the fish and the use of antibiotics to prevent infection of the tag incision and subsequent death of the fish or loss of the tags.

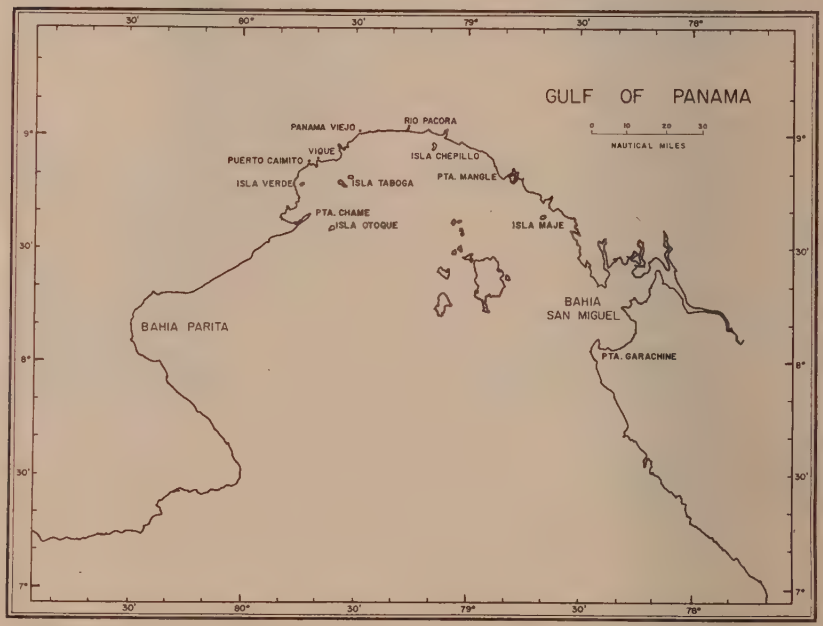

FIGURE 1. The Gulf of Panama, showing locations mentioned in the text.

The Purse Seine Fishery

Adult anchovetas inhabit the shallow mud flats along the coasts of the Gulf of Panama. They occur in Bahia Parita and almost continuously from Punta Chame to Bahia San Miguel (Figure 1). The young-of-the-year reach catchable size for the purse-seine fishery in about April or May, provide the main source of supply for the fishery through the summer and fall, and spawn

principally in November and December. During the fall and winter months their numbers (or at least their availability) decrease rapidly, so that year-old fish make up only a minor portion of the catch except during the winter and early spring. The purse seine fishery for anchovetas for reduction takes place chiefly between Punta Chame and Vique, an area of about 60 square miles. This area will henceforth be called Isla Verde, most of the fishery taking place near this island. The two reduction plants are located in this vicinity, one at Isla Taboga and the other at Puerto Caimito. The purse seine boats fish occasionally at Panama Viejo, and very rarely as far away as Punta Mangle.

MATERIALS AND METHODS

The fish for tagging were caught in shallow water within a mile or two of shore. A log canoe and cast nets were employed for fishing, the fish being put into the live well of the canoe. On several occasions fish were obtained from purse-seine boats fishing in the area; at such times the fish were dipped out of the bunt end of the seine into the live well of the log canoe. When sufficient fish were obtained they were taken to the tagging vessel, a 40-foot West Coast albacore troller, anchored in slightly deeper water. The fish were removed from the log canoe to one of two portable holding pens tied to the side of the tagging vessel. These pens were constructed of aluminum tubing and 7/16-inch stretch Marlon netting and were 65 by 41 by 48 inches deep. The pens were light and easy to handle and allowed the fish to have a plentiful supply of fresh sea water. However they afforded no protection from heavy wave action and strong currents, and could not be towed with the fish in them.

The fish were removed about 10 at a time from the holding pen with dip nets and placed into 2½-gallon plastic buckets containing fresh sea water with 0.2 gram per gallon of MS 222 (tricaine methanesulphonate) and 1 milliliter per gallon of terramycin in liquid form. The water was agitated about every 15 minutes with an electric agitating device, and changed at less frequent intervals. The fish were not left in the buckets long enough for the MS 222 to take its full effect, but it was helpful in reducing their struggles.

Nickel-plated iron tags 12 by 3 by 0.5 millimeters were employed. They were kept in groups of 100, because keeping an individual record of each tag would have been overly burdensome, and no advantage would accrue from such a procedure, since the fish were not measured when tagged and since only the tags, not the fish, were recovered in the reduction plants. The tags were kept in plastic soup bowls with a mixture of procaine penicillin G and terramycin, using 300,000 units of penicillin per 400 tags and enough liquid terramycin to make a pasty mixture that adhered to the tags and was exhausted at about the same time as the tags.

The tagging was conducted at tables specially constructed for that purpose, each containing a recessed plastic pan of sea water in which the fish were partially immersed while being tagged. The plastic bowls of tags were also recessed in these tables. The fish were removed one at a time from the buckets and tagged. The incision was made above the origin of the ventral fins with a Number 11 scalpel blade, the blade being inserted parallel to the body so as not to damage any of the internal organs. The blade was dipped into a vial containing a mixture of penicillin and terramycin before making each incision. The tag was inserted into the body cavity and pushed forward with the fingers

and the scalpel blade. The tagged fish were then dropped into the other holding pen. It was found that an experienced tagger could tag over 200 fish per hour for sustained periods of time. Two taggers worked simultaneously, so the maximum production per day was 3000 to 4000 fish.

When several hundred fish had accumulated in the second holding pen they were released in a group, since anchovetas are schooling fish and since aggregation in such species is considered to afford protection against predation (Brock and Riffenburgh, 1960).

RESULTS

The 1960 Tagging Program

Fish were tagged in all the major fishing areas of the Gulf of Panama except Bahia Parita and Isla Maje. A total of 53,380 fish were tagged, 15,370 at Isla Verde, 11,721 at Panama Viejo, 2,192 at Rio Pacora, 10,882 at Isla Chepillo, 6,629 at Punta Mangle, and 6,586 at Bahia San Miguel. The tagging was commenced on June 21 and continued through September 30. Several thousand fish were first tagged at Isla Verde and Panama Viejo in order to be sure that sufficient recoveries would be made when the fish were tagged and released in the area of the fishery; when this was confirmed the tagging was extended to more remote areas.

Magnets for recovering the tags from the meal were installed in the two reduction plants before the tagging program was begun, and tests were conducted at fairly regular intervals throughout the year to determine the percentage of tags that were recovered and the time lag involved. Each of these tests consisted of tagging 100 dead fish and distributing them in the unloading bins as the fish were unloaded. Disregarding tests made when the machinery at the plants was malfunctioning or other abnormal conditions were in effect, the efficiencies ranged from 87 to 93 per cent at the Isla Taboga plant and 84 to 92 per cent at the Puerto Caimito plant. At the Isla Taboga plant an average of 52 per cent of the tags was recovered after the first group of fish containing the tagged ones was processed. An average of 24 per cent was recovered after the second group of fish was processed, 6 per cent after the third "run," 5 per cent after the fourth run, and 3 per cent after the next seven runs. At the Puerto Caimito plant an average of 44 per cent of the tags was recovered after the first run, 41 per cent after the second run, 2 per cent after the third run, and 2 per cent after the next 11 runs.

A knowledge of the time lag between entry of the tagged fish into the plants and recovery of the tags is essential for studies of migration. The fish were sometimes caught in areas other than Isla Verde, so in order to assign areas of recovery to the tags, it was necessary to make decisions based upon what is known of the migrations of the fish, the time required for the tags to reach the magnets after entering the plants, and the areas of fishing during the periods under consideration. For instance only three tags that had been put on fish at Panama Viejo were recovered. Two of these were recovered following the first runs after fish from Panama Viejo had been landed at the plant, so it was considered that the fish with these tags had been caught at Panama Viejo. The other was recovered when only fish from Isla Verde had been landed at the plant for more than three months, so in this case it was considered that the fish with this tag had migrated to Isla Verde. The decisions as to the areas of

recovery of the tags are believed to be correct in the vast majority of cases although, of course, the nature of the recovery method precludes absolute certainty as to the area of recovery of any given tag.

A total of 425 recoveries had been made through October 8. Of these, 421 were tagged and recovered at Isla Verde, 2 were tagged and recovered at Panama Viejo, 1 was tagged at Panama Viejo and recovered at Isla Verde, and 1 was tagged at Isla Chepillo and recovered at Isla Verde. The fish involved in the last two recoveries were at liberty 3½ and 2 months respectively.

The fact that there is very little fishing for reduction purposes except in the Isla Verde area prevents the determination of the extent of migration of fish from this area. Since large numbers of fish were tagged in areas outside Isla Verde and only two of these tags were recovered there, it is likely that there was very little migration into the Isla Verde area during the period under consideration. Subsequent recoveries, however, may show migration into the area during some other season. Simpson (1959) suspected that there were spawning migrations because anchoveta eggs were found principally between Panama Viejo and Punta Mangle and because of the apparent lack of fish in some other areas during the spawning season; since spawning occurs principally in November and December these migrations are not yet in evidence.

Considerable variations in the percentages of recoveries made from fish tagged at Isla Verde on different dates are evident. The following recovery percentages were made from fish tagged in that area: June 21, 2.6; July 1, 2.6; July 12-13, 0.2; August 4-6, 3.3; August 10-12, 4.1; September 20-21, 3.6; September 29-30, 2.1. Naturally, all other things being equal the recoveries should be highest for the fish tagged earliest in the season. Detailed analysis of the catch and fishing effort data and other factors may shed further light on the reasons for these variations.

ACKNOWLEDGMENTS

Acknowledgment is extended to Dr. Milner B. Schaefer, Director of Investigations, and Mr. Clifford L. Peterson, head of the bait section of the Inter-American Tropical Tuna Commission, for valuable advice and assistance rendered to the program. Mr. Enrique J. Guardia assisted with the tagging in 1960.

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Movements Of Seatrout On The West Coast Of Florida

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Abstract

Spotted seatrout, **Cynoscion nebulosus,** do not travel great distances. Almost 95 per cent of recovered fish were taken within 30 miles of the release site. The greatest distance travelled was 315 miles. Fish which were returned were free as long as 22 months. More fish tagged at Cedar Key moved out of the area than did fish tagged at Fort Myers or Apalachicola. Fish were tagged with body cavity tags and with internal anchor tags which had a plastic streamer protruding from the body of the fish. The overall rate of recovery was 10.7 per cent. Streamer tags were returned at a faster rate during the first six months but after one year were less likely to be returned than body cavity tags.

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A World-Wide Approach To Fish Culture Improvement

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IT IS GENERALLY ACCEPTED that some kind of rudimentary fishing methods were known even to nomadic peoples. Certainly, fish was a well-known source of food in the earliest civilizations.

Not only have ancient fishing implements of good design been discovered, but also these activities were rather precisely recorded in such documents as the Mayan mural in the warriors' temple at Chichen-itza (Morley, 1956) or the Egyptian one dating from around 2500 B.C. found at Giza (Chimitz, 1957b) showing fishes which are easily recognizable as mullets, catfish and

characids still in the water, while two beautiful specimens impaled on the fisherman's harpoon are as clearly identifiable as *Lates niloticus*, the Nile Perch, and *Tilapia nilotica*.

Somewhat later the idea developed first of holding and then of raising fish in ponds. Another bas-relief from Egypt (Chimitz, 1957b) shows fishes clearly recognizable as Tilapia being caught by rod and line in a well-designed pond, some time before 2000 B.C.

Much clearer indications of rational methods for the cultivation of common carp are given by Fan Li (475 B.C.) in his "Practice of Fish Culture," while methods of collecting fish fry from rivers is described by Shi-ma (140-88 B.C.) and there are actual records of fish fry collecting and transportation in 1243 and 1639 A.D. (Lin, 1949).

Asia

The Tambak type of pond, developed in Indonesia, is also relatively ancient and is mentioned in the Javanese Law Code promulgated around 1400. Over 60 per cent of the fish consumed in Java are from these flooded areas, as is easily appreciated when flying over the hundreds of miles of tambaks when traveling between Djakarta, Madura and Bali. About 200,000 acres of such artificial lakes produce about 33 million pounds of milkfish, *Chanos chanos*, each year (Schuster, 1952), with some incidental shrimp. Over the centuries, the property right of these ponds have passed from the Hindu kings through the Muslim rulers, the East India Company and the British Crown, until in 1860, the ponds were the property of the people, although a special system of supervision through the local "mantris" keeps the system alive. This is perhaps one of the most massive fish culture operations which has ever existed anywhere or at any time and it has been calculated that 500 million cubic yards of earth must have been moved by hand to give the ponds their present shape (Schuster, 1952). Chanos culture, based on the old Indonesian practice, has also been found profitable in the Philippines, Thailand and other areas of the Far East. It is perhaps not true fish culture, insomuch that the larvae produced at sea by this catadromous fish migrate to shallow brackishwater inlets and so can be systematically let in to artificial lagoons. It is surprising that similar systems are not in use in South America, since the milkfish is also found in the Eastern Pacific.

Another instance of the practice of raising fish from fry produced by wild stocks is the ancient trade which has developed, in Bengal, in the major carps of India—*Catla, Cirrhina* and *Labeo* spp. In fact, three quite separate industries support many thousands of operators: a) those who locate the migrant streams of fry and capture them in fine funnel-type nets with a cod-end and sell them to b) those who raise them from fry to fingerlings, and in turn sell them to c) those who raise these to marketable size (Job, 1951).

Again, in China several carps which are not known to spawn in captivity are captured as fry and raised in ponds, the most important being the big-head, *Aristichthys nobilis;* the silver carp, *Hypophthalmichthys molitrix;* the mud carp, *Cirrhina molitorella;* the black carp, *Mylopharyngodon piceus*, and that interesting fish, the grass carp, *Mylopharyngodon idellus*, which is the most effective eater of hard cellulose plants known and hence most useful, in combination with other fishes, in keeping the ponds free from weeds. Although until recently the grass carp was only known to spawn in the rivers of the

Canton area in China, and stubbornly resisted transplantation, recent reports indicate that it may have established itself in Japan, and it is being used in the U.S.S.R., although there is no indication that the Russian workers have successfully spawned it.

Several other species are used in the Asian systems—the minor carps of India, several species of catfish in Viet Nam and Cambodia, the Tawes, *Puntius javanicus,* and Nilem, *Osteochilus,* and several *gouramis* in Indonesia. Predators are not merely available and utilized, but can easily decimate a pond if measures are not taken to keep them out (the murrel or snake head, *Ophicephalus,* the bekti perch, *Lates calcarifer,* etc.).

In 1939 five small fishes were found by a Mr. Mudjair in a stream in Eastern Java and identified in the Netherlands as belonging to the genus *Tilapia.* Although the manner in which they were introduced to Java is officially stated to be unknown, there would seem to be no mystery about this, and it is fairly certain that this is just another case of an aquarist dumping his fish in the nearest stream before leaving for home.

However this may be, its propagation was encouraged by the Japanese during the occupation, and it became the fashion after World War II to talk of *Tilapia* as a "miracle fish," and for some reason, perhaps because FAO had a very active and efficient fish culturist there, much of the *Tilapia* which was disseminated throughout the world came from the King's ponds in Bangkok rather than from their native Africa. It has been our sad duty in FAO to call attention to the fact that *Tilapia mossambica,* the species which caused all this furor, is only one of the many different species of *Tilapia,* which in turn is just one of the numerous genera of the cichlid perches which are common to Africa, the Levant and the American tropics, and that the *Cichlidae* are only one relatively unimportant family among the host of freshwater fishes.

The great drawback to *Tilapia* in ponds is that, without very careful management practices which are usually not available to the rural farmer, the very combination of fecundity and precocity, which made it famous, soon gives rise to serious overproduction and stunting, which may result in failures in otherwise promising fish culture programs.

Notwithstanding the rather satisfactory understanding in Asian countries of the advantages of diversification, and the great contributions already made to pond culture practices, knowledge is confined to the local species (with the sole exception of Tilapia) and Asian fish culturists will stand to gain much more from a more universal approach, particularly when the full significance of the South American species is more apparent.

Europe.

The history of fish culture in Europe is more recent, although common carp, *Cyprinus carpio,* appear to have been introduced as early as the middle ages. However, the common carp is not universally popular as a food fish and selected varieties, known as mirror carp, leather carp, etc., have been produced in Germany and Israel. Apart from trout and salmon, which warrant separate treatment, there has been no really significant cultivation of other species, although some work has been done with such fishes as tench, bream, etc.

As in many other fields, the U.S.S.R. is making considerable progress in fish culture. According to Wurtz (1960), "no type of fish pond culture has been neglected in the U.S.S.R.", and of special interest is the work of Montchan

and Martichev in the Ukraine with the Chinese grass carp—the first instance outside Japan where serious attention has been paid to this valuable plant-eating fish—combined with crucian carp, tench and bream, with yields up to 5 metric tons per hectare. The U.S.S.R. methods based on heavy fertilization and what would elsewhere be called over-stocking, are also in use in Bulgaria. At the Mydlniki and Ochaby annexes of the University of Cracow (Poland) experiments are being carried out on combinations of Polish carp breeds; whitefish, *Coregonus* and pike-perch, etc.

North America

In the United States, common carp, introduced in the middle of last century, is considered to have become a plague, principally because the demand today is for sports fish rather than species which are fast and efficient protein producers, but also because of an early policy of rough release, rather than the pond culture of its selected forms.

Considerable imagination was evident in the United States around the turn of the century, when great effort was expended in artificially producing many species of fish and crustaceans for release in the rivers, and even in the sea. These activities were dropped when later scientific investigations indicated that the amounts of fish so artificially produced did not in any way affect the wild stocks. There has been considerable emphasis on the combination of the largemouth black bass, a predator, with small sunfishes as fodder. Apart from some success with several species of catfish, it cannot be said that there has been any great diversification in warm water fish culture.

It is, however, perhaps not surprising that in two of the three countries of North America where the temperature drops to the freezing point in winter, great progress has been made in the cultivation of trout and salmon. We are not particularly concerned with the salmonids in this paper, because they do not lend themselves to combinations with other fishes, as do the species which are adapted by nature to warmer waters.

Artificial propagation of the trouts and salmons is a historically recent activity. Although Jacobi of Germany around 1741 developed the techniques which are still essentially those in use in most places today, it was not until approximately the turn of this century that great activity was to be observed in this respect. Around this time the importation of European, and later North American, salmonids became fashionable, brown and rainbow trout having been universally successful introductions into almost every country where the water is sufficiently cold at least during part of the year. Hatchery methods and planting policies remained stereotyped until about 1936, when, as a result of organized research in the U.S., new techniques such as malachite green as a fungicide began to be developed, and it is unfortunate that many countries with excellent climates for trout and salmon propagation still continue to breed and plant trout on the old, hit-or-miss lines which are a century out of date, and do not profit from the U.S. experience.

Africa

In Africa, there has since about 1924 been great activity in promoting the cultivation in farm ponds of several species of the cichlid perches of the genus *Tilapia,* and a good deal of work has been done on this group by the biologists of the ex-metropolitan powers, Belgium, France and the United Kingdom,

which will no doubt be continued and perfected by the fisheries workers of the newly independent countries of that Continent. Apart from some experimentation with the Nile perch as a predator, this author has no recent information in respect of diversification of species.

South America

It is surprising to find that, notwithstanding the very large number of tropical fishes native to South America, no indigenous fish culture practices have arisen and in most countries of the area this promising source of food has been completely neglected, principally because governments have not yet found it possible to finance and encourage fisheries investigations through the preparation of professionally trained people, there being little inducement at present to make a career of what is still an unremunerative field. Fortunately, there are signs of activity in Brazil, where some good work has been done and the results published in Portuguese. It is believed that Brazil may in the future make the greatest contributions, in the way of on-the-spot investigations on the life history and adaptability to cultivation of the two great groups of freshwater fishes, the Characidae and the Cichlidae, which will probably be the most promising source of new material.

I have not referred to the work which has been done in Brazil, Argentina and Chile on the larger silversides, *Atherinidae*. This was at one time promising but has apparently lapsed. The renewal of work on this group in the countries concerned, and also in Mexico with *Chirostoma estor,* another valuable but neglected atherinid, in combination with other fishes, would be valuable.

Central America

Little has been done in Central America, for the same reasons, but with more justification, the indigenous fauna being a rather poor overflow from that of South America. However, Guatemala, El Salvador and Honduras have for some years now had a freshwater fisheries investigation program with assistance from another FAO fish culturist as a result of which some work has been started with a little-known but encouraging cichlid, *Cichlasoma dovi,* which grows to a very large size in Lake Managua.

On the question of exotic introductions

Much has been written on this subject, and most of the literature is badly slanted against exotic introductions, with constant repetition of the harm done by such haphazard examples as the sparrow in North America and the rabbit in Australia, but forgetting the enormous benefits brought to the new world with domestic cattle and poultry, and the horse, which infinitely outweigh the harm which may have been done by the uncontrolled importation of useless or harmful species.

In the case of fishes, most of the introductions of trout and salmon have been into waters which previously held little or no economically important fauna. Importations of Black Bass to many parts of the world have been criticized, but in many cases (Colombia, Viet Nam) it is found on examination not to have survived, and in cases where it has (Guatemala) it has sometimes formed the basis of a valuable wild fishery where none existed.

The common carp is, of course, the villain of the piece, mostly because of the aversion in the United States to any freshwater fish which does not provide sport. This is, at present, not a valid argument in most countries, where cheap

and abundant protein is the main consideration, and no fish is superior to the common carp in this. However, it is true that only selected varieties should be used, and those in ponds, and that the common carp is not a sound introduction into any wild fishery.

Any species of fish can, in fact, be beneficial or noxious according to whether or not it is wisely used. There is certainly no point in loading up reservoirs with fish which, although not eatable, consume part of the available foods (Brock, 1952) *unless* they can subsequently serve as forage for a suitable predator.

It must, however, always be kept in mind that an introduction to wild waters which happens to thrive, is irreversible, and that in many cases just a handful of progenitors have produced billions of offspring — five Tilapia in Indonesia; fourteen bluegill and one hundred crabs in Hawaii (Brock, 1952) etc. On the other hand, if a species is proved after experimentation not to survive, there is usually little point in wasting effort in repeated trials. There is really no such thing as "acclimation" in fishes, although government officials (who should have known better) have made costly efforts to introduce prestige fish such as trout, and even Pacific salmon, into climates in which they could not thrive and where some other form would have been at the same time more successful and more useful.

The lack of co-ordination

The above brief information on fish culture which has been, and is being, performed in various parts of the world, is not intended to be exhaustive, and apologies are no doubt due, and are hereby offered, to many investigators whose work has not yet become generally known.

Rather has the intention been to indicate, firstly, the serious gaps in our knowledge regarding the many species of fish which will no doubt turn out to be valuable additions to the rather limited list of the domestic and domesticated animals at present used for human food, and secondly, the amazing fact that although there is much information, published and unpublished, on the fishes cultivated in different geographic areas, this fund of knowledge is put to little practical use outside the immediate place of origin, so that a very large number of permutations of compatible mixtures which would take maximum advantage of every ecological niche and produce an optimum (i.e. the most profitable) yield per unit of area, is neglected.

International co-operation

Over the last ten years, it has become part of the foreign policy of those countries which have achieved an "advanced" stage of technological development (i.e. those which have undergone a well-defined industrial revolution) to lend their technical skills to that other group of nations which used to be called "backward" but which are now more charitably known as "underdeveloped," or "in the process of development." This technical aid may be bi-lateral (from one government to another), or multi-lateral, i.e. channeled through the United Nations Specialized Agencies, the Colombo Plan, etc.

This is, in the great majority of cases, a one-way traffic, but in this peculiarly neglected field of fish culture as a source of food, there is as yet no one adequate source of knowledge whether in the East, West or South, and progress must therefore not depend on the usual presumption of superior knowledge, but rather on the painstaking compilation and comparative analysis of

practices which have been empirically developed all over the world. Furthermore, the most promising unknown sources of fish culture material are the "underdeveloped" countries, where competent biologists will contribute greatly to our knowledge, provided they have the tools to do the job!

There are, for instance, promising indications that, among the fauna which is broadly common to Africa and South America — the characids and cichlids —and of which only the systematics are known, there exist species which, to cite an example, are as efficient browsers on cellulose plants as is the Chinese grass carp, and probably much more manageable.

A solution

The shortcomings which have here been brought to light, neither for the first nor the last time, could be fairly easily remedied, the crux of the whole question being, as usual, who is to do the work, and, where do we find the money.

Certainly considerable funds would have to be invested in a) investigating the imperfectly understood life habits of many species of fish, especially in Africa and South America; b) compiling the existing knowledge, which is considerable; and, c) actual exchange of fishes between geographically distant countries for d) experimentation in sufficiently large pond areas with a view to discovering the best fishes for each ecological niche. It is, however, predictable that, given a "critical mass" of conscientious research, the return would add up to many hundred times the investment.

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The Contribution by the Outboard Motor to the Mechanization and Development of the Fishing Industry

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THE MECHANIZATION OF FISHERIES through the medium of the outboard motor has improved the economy and raised the standard of living in more than a score of countries throughout the world during the past six years.

Everyone recognizes the importance of raising economic levels, but many are inclined to ignore one result of increased fisheries production which today assumes an importance equal to that of economy—improved nutrition and a better balanced diet. Increased wealth is important only when it provides a corresponding rise in health.

The Food and Agriculture Organization of the United Nations, which has been conducting a world-wide survey of food requirements, reports that today there are millions who do not have *enough* to eat, and additional millions who do not have enough of the right kind of food to be well and strong. This survey, in which the 76 member states cooperated, reveals that by 1980 the world cereal production must be almost doubled and the fish production increased by more than 80 per cent if the population is to be fed at present levels. At the same time, the report stresses the fact that the present levels are not adequate.

The world production of fish is approximately 30 million tons, of which 75 per cent is produced by only eight countries: Japan, United States, China, Russia, India, United Kingdom and Canada. The rest of the world, and this includes nations where animal proteins are in dangerously short supply, contributes less than 25 per cent of the world's fish.

During the past six years this picture has gradually been changing, and if the mechanization programs carried out by government agencies and private organizations of many countries are continued, the improvement will be accelerated.

The outboard motor, for many years viewed as a recreational toy, has been responsible for the improvement of numerous small craft fishery programs and in some instances has been responsible for increases in fish production of more than 1,000 per cent.

In the areas of major production, the large fishing vessel produces the major portion of the marine crop. But in the majority of the fishing grounds throughout the world the use of a large, costly vessel would be economically impossible, as the fishing methods could not be accommodated to local fishing conditions.

This places the responsibility for fish production on small craft, normally one-man or two-man operations. Restricting the propulsion of such craft to sail, oar and paddle limits the range of the boat to waters in the immediate vicinity, and precludes the possibility of the fisherman harvesting more productive waters. At the same time, it seriously restricts him as to markets, which would provide a more lucrative return from his limited catch.

The mechanization of these small fishing craft by means of the outboard motor, which has proved adaptable to every form of local boat, has been possible because of the low initial cost and economical operation of these

propulsion units. The extended operating area resulting from such mechanization has made it possible for the fisherman to reach productive fishing grounds that were formerly too distant for practical use. At the same time, it permitted him to reach better markets in a shorter time and receive a higher return from a larger catch. The improved economy and the resulting standard of living has a beneficial effect on the national economy as well as raising the nutritional level.

Some of the larger, wealthier, and healthier countries are unable to appreciate the importance of fish to nutrition, or to national health. Unfortunately, children are the real sufferers from the illness resulting from diet deficiencies. These ailments, stemming from a common source, have many names. In Central Africa it is "kwashiorkor," in South Africa "infantile pellagra" and in Jamaica "fatty liver disease" or "sugar baby." All stem from lack of protein and in many areas the only protein source, because of the twin factors of availability and cost, is fish.

Surveys have revealed that localities where mechanization has resulted in greatly increased fish production have shown an almost immediate decrease in nutritional ailments, a lower infant mortality rate and a higher health incidence.

The development of outboard motors in higher horsepower units has done much to stimulate the commercial application of this compact power plant, especially among commercial fishermen. Prior to mechanization few small fishermen could afford to install an expensive inboard engine, which normally calls for extensive change in boat design or the purchase of a boat designed for inboard power. Also, only a small portion of the boats used were adaptable for inboard installation.

The outboard, in addition to being available at a lower cost, offering a horsepower range sufficiently wide to insure adaptability, and being adaptable to almost every type of small fishing craft, was simple to operate and insured easy maintenance. These factors were of major importance, even in instances where government-sponsored mechanization programs provided long-term loans for the purchase of motors and fishing gear. Few such programs were sufficiently financed to permit broad mechanization if large diesel or gasoline engines were to be employed. It was learned that a dozen small craft could be mechanized by means of the outboard motor for the cost of one inboard installation.

A number of government fishery agencies as well as the F.A.O. have made surveys to determine the exact degree of economic benefits derived through outboard mechanization. The greatest benefits have been obtained by the smaller nations, which has proved fortunate, as many of these countries stood in greater need of economic improvement as well as improved nutritional conditions.

The experimental outboard mechanization program carried out by Puerto Rico is an outstanding example of the benefits to fishery production.

During the fiscal year 1958-59 the program provided motors for 21 fishermen, and the following year an additional 116 were provided. The government loan amounted to $37,714, with $3,976 invested by fishermen.

In January 1960 a study was made to determine the effect of the mechanization on fish production and on the fisherman's income. A sample cross-section involving 39 fishermen was checked. The average weekly catch jumped from 134 to 201 pounds, or approximately 50 per cent. The 39 fishermen increased their annual fish production by 68.5 tons. The average gross income of these

fishermen was $26.19 before mechanization and $39.47 afterward, representing an increase, after expenses, of $360 a year per fisherman. For the commercial fisherman whose annual income prior to mechanization was around $1,000, this represents a marked increase.

Felix Inigo, chief of Puerto Rico's Fish and Wildlife Section, reports that the program is being accelerated and with 365 of the 1,091 fishing craft now mechanized, the entire fleet should be mechanized by 1965. The results have been so satisfactory that the program has been extended to cover other phases of the fishing industry. Loans are now being approved for the improvement of boat yards and for transportation facilities to market the catches.

On the basis of increased production, the results of outboard mechanization in the fisheries of Ceylon show the most marked improvement. A survey by the F.A.O. was made in three typical fishing areas, Ambalangoda, Balapitiya and Kalutara. A total of 30 fishing craft were included in the survey, 15 mechanized and 15 non-mechanized. The mechanized fleet docked with a total weight of 3,190 pounds of fish with a value of 2,120 rupees. The non-mechanized fleet, during the same period, brought in a total of 193 pounds, with a value of 230 rupees. In this instance mechanization resulted in a production increase of more than 900 per cent, in terms of increased income.

In Ceylon, as in several other countries, the initial steps in mechanization created problems that were solved by education and example. Many of the fishermen, especially in the more isolated areas, were completely lacking in any knowledge of things mechanical. Individuals knew the advantages and limitations of propulsion by sail and oar, but many of them had never seen a motor. Despite the simplicity of operation of the outboard and the ease of maintenance, it was necessary to carry out a course of instruction that would insure elementary mechanical aptitude.

The F.A.O., convinced that mechanization was the only means of increasing fish production in Ceylon, found the average fisherman apathetic concerning the advantages of mechanical propulsion. The initial program involved three fishermen, who were provided with motors with the understanding that if they did not find them satisfactory after a six-month trial they could return them without cost. One fisherman gave up after a three-month trial. The other two persisted, and the increased catches so influenced other fishermen that more than 100 negotiated for motors. The interest in mechanization eventually reached the point where some fishermen began building boats with motors and chartering them to those in neighboring villages.

With the increase in mechanized craft came improved communications. Fishermen able to transport their catches to more distant and remunerative markets made the return trip to their villages with goods that otherwise would have had no distribution. The resulting increase in income stimulated trade in many products, resulting in better living conditions and a greatly improved standard of living. The fisherman, now able to afford items that formerly were classified as luxuries, stimulated the production of these items, which in turn benefitted other fields.

One government official described the introduction of the outboard as having "created a wake that washed prosperity in many forms to the shore of the waters of its origin."

Another effect of mechanization was to partially eliminate the insular character of the more isolated areas by opening up communications with distant

villages and bringing about the exchange of cultures previously impossible. The benefits in many instances have been cultural as well as economic.

Several countries, such as Mexico, Colombia, the Republic of Senegal and several others, introduced mechanization without the benefit of governmental programs. In some instances the development was initiated by fishing cooperatives, in others by the zeal of distributors who arranged the sale of motors to fishermen on a finance plan.

The development of mechanization itself was not without its problems. In most instances this involved maintenance and repair. This was solved in several ways. In one instance a fisherman's cooperative in Malaya set up a repair shop staffed by a trained mechanic, and carrying supplies of necessary spare parts. In the Republic of Senegal, West Africa, a distributor organized a mobile repair shop in the form of a truck, staffed by a mechanic who not only carried out repairs but instructed in both maintenance and repair. This truck made regular visits to all fishing areas. In several instances the government provided these facilities as part of its mechanization program.

Jan-Olof Traung, chief of the Fishing Boat Section of F.A.O., speaking at the International Economic Conference on Small Craft for Fisheries and Transportation last May, urged that the development of fishery mechanization be initiated by individuals and groups in countries where governmental programs were not available.

"Even in those countries where such programs are scheduled, they are often delayed. Governmental action is normally slow, as the agency charged with effecting the program faces problems that are not encountered by individuals or private organizations. The formulation of rules and regulations for financing often requires months, and the very machinery of investigating individual cases is slow, resulting in costly delays."

The conference on Small Craft for Fisheries & Transportation, sponsored by Outboard Marine Corporation and OMISA, was attended by ambassadors, consular officials and fishery representatives from 37 countries. It served to disseminate information on the application of outboard motors in commercial fishery and transportation activities in a score of countries. A number of papers were presented on the successful methods of mechanization employed throughout the world, with detailed information on the problems encountered and their solution.

Financing has proved to be an obstacle in many areas where mechanization would have been extremely productive. Even in localities where boats are suitable and the fishermen are eager to obtain power for their craft, they lack the means to purchase equipment. Often local merchants, while aware of the potential, do not have sufficient funds to establish time-payment programs. In some cases outboard distributors and dealers in the Republic of Colombia established programs through local banks which made it possible for capable fishermen to finance motors. This practice has also proven to be successful in Tanganyika and Trinidad and is being encouraged by Outboard Marine International S.A., which provides information on the organization of financing programs.

In Chile the initial mechanization program was started by a merchant, who sold them to fishermen on a hire-purchase basis. The development was slow initially, as the merchant was unable to afford long-term financing. However,

when other fishermen recognized the advantages offered by the outboard they made every effort to avail themselves of mechanization.

In some instances the governments themselves, indirectly, prevented the growth of mechanization by failing to reduce the tax on gasoline for commercial fishermen, which resulted in prohibitive operating costs. Several governments recognized this situation and took steps to eliminate the problem. Jamaica led the way in this development.

Following the inception of a sound mechanization program, which made outboard motors available to fishermen on long-term loans, the Jamaican government provided ready-mixed gasoline to fishermen free of "all" tax. The normal price of gasoline in Jamaica was 56 cents per gallon, but commercial fishermen were able to buy it at one-half this price. As the oil was mixed with the gasoline prior to sale, there was no problem involving the diversion of this fuel to the operation of other vehicles. As a result of these forward steps, fishery production in Jamaica has multiplied, resulting in a marked improvement in the economy.

Among the international organizations which have turned to the outboard as a means of improving living conditions, the program initiated by CARE provides an excellent example. Begun in the Philippines, this program is being extended to other areas.

Restricted catches resulting from a lack of mobility prevented fishermen in many Philippine villages from taking advantage of productive fishing grounds. CARE improved these conditions by providing one of the boats with a motor, making it possible to tow several other craft to distant fishing grounds where greatly increased catches were possible. This resulted in improved living conditions in each village where the program was tried. The success of the CARE plan led to a decision to expand this program to other countries during 1961.

The Outboard Marine Corporation (OMC) has a deep interest in such far reaching programs which are aimed at improving conditions for mankind, particularly in under-developed countries. In the case of CARE for example, that organization maintains 30 missions throughout the world. Conveniently enough, OMC has had distributors in those countries for many years. The objectives of both CARE and OMC, as a joint venture, are to assist local fishermen to mechanize their craft by means of outboard motors.

It is not the intent of such joint programs to saturate any given area with outboards. The principal target is to develop a number of pilot projects designed to assist fishermen to extend their area of operation, to enable them to increase the time they allot for fishing, and to permit them to return to market more rapidly, without suffering spoilage.

In areas where such pilot projects show effective results, they will be continued as a large scale operation. The Outboard Marine Corporation donated 50 outboards to CARE to initiate the program.

The adaptability of the outboard to local craft of varied design, size and displacement has enhanced the value of this power plant to the commercial fisherman. Motors are available with standard or long shaft, insuring acommodations to transoms of various height, and propellers of assorted pitch and diameter are available which permit the motor to be adapted to light or heavy loads. The horsepower range of the outboard now available from 1 to 80 h.p., provides a versatility that cannot be matched by inboard engines.

In addition to its contribution to the increased production of fisheries, the

outboard has made it possible to establish transportation routes in areas where waterways were the only highways. In addition to improving communications with isolated communities, the introduction of the outboard in such areas as Brunei State, Borneo, Thailand, Indonesia, The Philippines, and several others, led to the use of other mechanical equipment. In many instances the transportation of such equipment was made possible only by the use of outboard-powered craft.

The improved transportation facilities that resulted made it possible for the farmer and planter to get his products to market faster and at a lower cost, with a resulting improvement in economy.

In addition to health improvement attained through the increased production of fish and the attendant increase in the protein requirement, the outboard made improved medical care available, even in isolated areas. In the Bahamas, for example, a medical officer is now able to serve a dozen communities through the use of an outboard boat. In times of disaster, medical aid, food and relief equipment can be transported without delay, which has resulted in the preservation of life and property.

A score of examples can be pointed out, highlighting use of the outboard during times of disaster. They serve to transport relief equipment conveniently and without delay. When spring tides, swollen rivers and northwestern gales spilled flood waters over Holland's dikes last year, creating one of the most disastrous inundations in the country's history, the Dutch Red Cross and the Corps of Engineers put outboards into operation in flooded area, with excellent results.

Outboards, in the service of the Royal Danish Life Saving Squad, have played a vital role negotiating treacherous waters. The British Navy's salvage squads frequently depend on outboards. When flood waters of the Kariba Dam in South Rhodesia threatened to wipe out thousands of helpless animals, rescue teams, using outboards, transported and guided them to safety.

Outboards are used, and have been used in many areas, under many different circumstances and conditions throughout the world. No longer can the outboard motor be regarded as a recreational toy. In more than a score of countries where recreational boating is little known, the outboard has proved to be an important industrial workhorse, with a potential that even today has not been fully explored.

Effects of Pesticides on Commercial Fisheries

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THE NEED FOR AN EXTENSIVE and continuing research program to determine the effects of agricultural chemicals on our fish and wildlife resources has been apparent for many years. The ever-increasing amount and variety of these chemicals in use on farms and forests have made the problem one of national concern. More recently, the need for comprehensive studies in the estuarine environment has been recognized, and various agencies have initiated limited

investigations in this area. Much of the research done in the past has demonstrated that these chemicals may be highly selective in their toxicity even to closely related forms. Although they have been developed primarily for their toxic effects on particular groups such as insects, rodents, or weeds, some have had unexpected and disastrous effects on associated biota. Their effects may vary widely in different environments depending on meteorological conditions such as wind and rain. The character of the soil, and in aquatic habitats the water chemistry and types of sediments, may greatly influence their toxicity.

Knowledge of these variables alone makes it highly desirable that thorough studies be conducted in our estuarine habitats where more than thirty of our most important commercial species of fish, shellfish and crustacea spend a part or all of their lives.

There are other and more compelling reasons why intensive investigations of this type of chemical pollution are needed to protect our fishery resources.

Despite the fact that a majority of the pesticides are only sparingly soluble, it is inevitable that sooner or later significant amounts of them will collect in our rivers and estuaries, either as particulate matter, adsorbed on silts and detritus or perhaps in some new chemical relationship.

It must be noted that many of these chemicals are in use today because of their specific toxicity to arthropods. Yet it is an arthropod, the shrimp, our most valuable commercial species, which utilizes estuaries as its nursery grounds. In this same group, of course, are both kinds of lobsters, the blue crab and the stone crab, all of considerable economic importance.

It is a matter for especial concern that marine bottom forms including clams and oysters may be unusually susceptible to these chemicals. They may be poisoned by them, or what could be more serious, they may concentrate these poisons in their digestive organs and other body tissues. Unfortunately it is just these forms which we use whole and frequently unprocessed as food. The analogy here to the situation in which birds were poisoned indirectly by eating earthworms that had concentrated pesticides in their tissues is both appropriate and threatening.

There have been accidental but dramatic instances in which extensive mortalities occurred to fish and crab populations in different areas as a result of insect control programs. Such incidents are, however, the exception and our real problem concerns the immediate and long range effects of pesticides reaching estuarine areas indirectly.

At present, we do not know how much or what pesticides are being transported from farm and forest lands through drainage basins into the estuaries. We have no dependable qualitative and quantitative tests for identifying them when highly diluted in the marine environment. We do not know if degradation products of these pesticides, formed in transit, are more or less lethal to marine fauna than the parent chemical. Nor do we have much information on the cumulative effects of sub-lethal concentrations. The possibility of synergistic effects with other environmental components is an untouched field for investigations.

The fluid medium of the estuarine environment makes it much more possible for harmful combinations or sequences of events to take place than in terrestrial applications of these chemicals. Consequently, it is difficult to predict from laboratory testing programs the end results of field applications. There are

inherent difficulties in maintaining most of the commercial species of fish and shellfish for long periods under laboratory conditions.

For these reasons, much of our initial effort has been devoted to relatively rough screening programs of the most important pesticides and to the development of appropriate bio-assay techniques.

During the past fiscal year, Bureau of Commercial Fisheries laboratories have made considerable progress on the overall problem. Examination of the accumulated data has been discouraging, not because of a lack of results, but because they demonstrate the complexity of the problems with which we are faced.

Some of these results I should like to review briefly and indicate their possible implications.

The Biological Laboratory at Milford, Connecticut, because of its excellent technical facilities and experience, has concentrated its efforts on studies of phytoplankton and molluscan larvae in relation to pesticides. Their studies have shown the extraordinary toxicity of some of the herbicides to the unicellular phytoplankton utilized by molluscan larvae as food. One of these, lignasan, was highly toxic at concentrations of only a few parts per billion. The other herbicides tested were toxic at much less than one part per million and this was true for many of the insecticides as well. It is obvious what disastrous effects relatively small quantities of such chemicals could have in upsetting the food web in a restricted estuary.

Of equal concern are their findings that many of the most common insecticides have a strongly toxic effect on oyster and clam larvae. Relatively high concentrations, up to 1 ppm, were required to cause significant mortality, but at lower concentrations, growth rates were invariably decreased.

The Galveston Biological Laboratory has conducted an insecticide screening program with emphasis on commercial species of shrimp. Their data show that all of these chemicals are extremely toxic to shrimp, causing 50 per cent mortalities at concentrations of less than 50 parts per billion. Equally disturbing is their finding that the same chemical may have entirely different toxic values when formulated with different so-called inert carriers. For although there are only 200 or so basic chemicals in use today, the number of formulations runs into the thousands.

The Biological Laboratory at Gulf Breeze, because of special facilities for evaluating the activity of oysters, has concentrated its efforts on, first, a screening program to determine the toxicity to oysters of the common pesticides, and, second, to the development of better techniques of bio-assay.

In working with oysters, the concept of LD_{50}, or the concentration of a poison causing a 50 per cent mortality in a given length of time, has little meaning. If oysters don't like their environment they close their valves and effectively remove themselves. Consequently, in our testing programs it is necessary to use concentrations of the pesticide sufficiently dilute to prevent the oyster from closing.

Initially, pesticide toxicity was evaluated by determining the number of hours per day test animals were open and presumably feeding. Continuous kymograph recordings were made of their shell movements in order to measure their activity. Under these conditions, it was found that their activity might appear to be unaffected for days or even weeks at a given concentration of a chemical before adverse changes could be detected. As a double check on the value of activity data, records were maintained on weekly growth increments of young

oysters kept in the same aquaria. It was soon found that not only were growth increments equally reliable, but there was no time lag in the appearance of adverse effects as shown by decreased growth rates. A logical sequence to these results was to discover how long a time interval was needed to establish changes in growth rates. Obviously, tests requiring four to six weeks for conclusive results, as in the shell activity work, are of limited value in a program faced with testing hundreds of chemicals.

We have now standardized our methods for using the growth rate of young oysters as an index of chemical pollution and they merit a brief description here. Small oysters from 1-1½ inches in length are used since they grow in all months of the year in contrast to larger oysters in our area. The posterior or open end of the valves is filed with a rasp until all of the membranous or soft new shell growth is removed. The removal of this shell does not harm the tissues of the oyster which contracts internally when it is handled. With moderate care there is no danger of actually making an opening into the shell cavity. Control and experimental groups are then placed in suitable containers of circulated untreated and treated sea water. Measurements of shell deposition are made at convenient intervals, usually daily for three days, using an ocular micrometer with low magnification. Records are maintained on the growth increments of the oysters individually.

We find that only 10 oysters are required to provide data for a statistically valid sample. Within a wide range of hydrographic conditions, control oysters will deposit approximately one mm of new shell growth per 24 hours. Since a control group is used, there is no necessity for maintaining constant salinity and temperature levels. One day's observations are normally sufficient to determine the required range of concentrations to be tested and three day tests provide definitive results.

Obviously this technique can not be applied to work with mature fish and crustacea but perhaps it is applicable to larval forms which grow fast enough so that changes in rate of growth may be quickly observed.

Both the Milford and Gulf Breeze workers have noted that the first evidence of toxicity of pesticides to shellfish is a decrease in growth rates. It is reasonable to suggest that our ability to evaluate this item may eliminate much costly and time-consuming work in the future. We are interested not only in the pollution levels causing acute toxicity and death, but also those causing more subtle reactions which over a period of time may affect reproductive potential and longevity.

Using the growth of small oysters as a criterion of pesticide toxicity, we find two points of particular interest. After the lowest concentration of a chemical that causes a decrease in growth has been determined, we find that exposure to a further ten-fold dilution produces no apparent ill effects, even over a period of several weeks. Secondly, when adversely affected oysters are returned to clean sea water, the normal growth rate is reinstated within a short period of time, usually a few days.

We may hope that so far as oysters are concerned, and perhaps other estuarine forms, that not only are subacute toxicities transitory but that they may be avoided by relatively small increases in the dilution factor. It is possible that under natural conditions, and barring accidents, average dilution factors are so great that these chemicals pose no real threat to estuarine and marine forms.

These items are not suggested to lull us into any feeling of security with

regard to chemical pollution but rather to point out how a coordinated and productive research program can provide the basis for better resource management. Agricultural chemicals are here to stay. With sufficient knowledge of their immediate and residual effects, it will be possible for us to utilize them to the fullest extent and with minimum damage to our valuable natural resources both on land and in the sea.

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